

AUGUST 1951



VOL. 43 • NO. 8

Journal

AMERICAN
WATER WORKS
ASSOCIATION

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Deep Well Pump Maintenance

Thomas

Fluoridation—Sound Public Health

Cox, Ast

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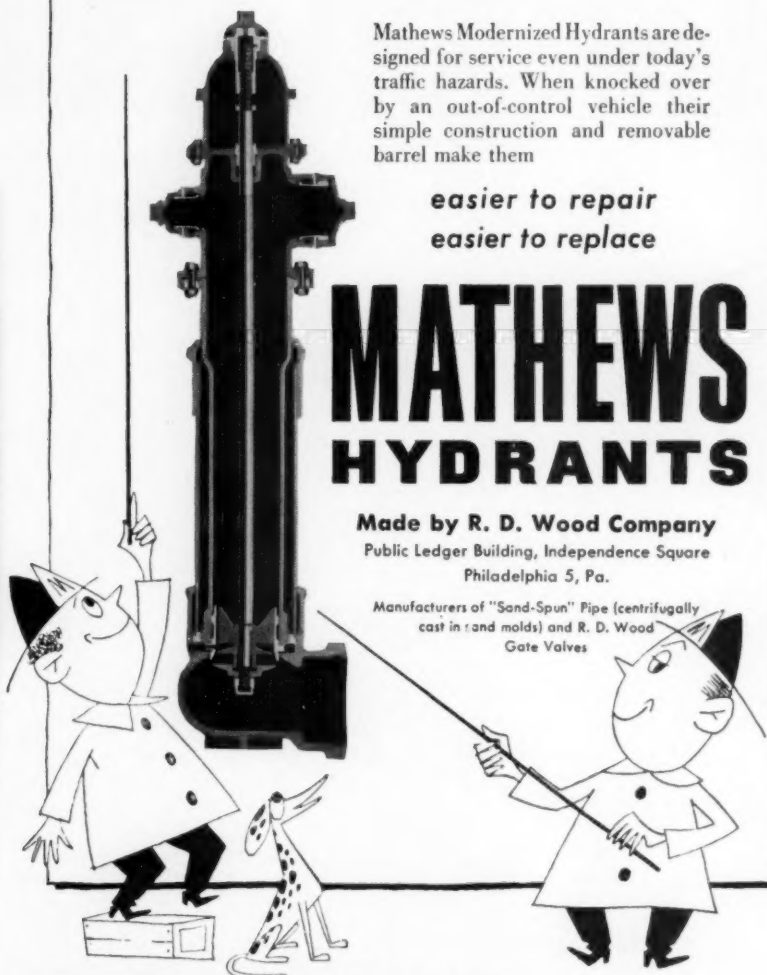
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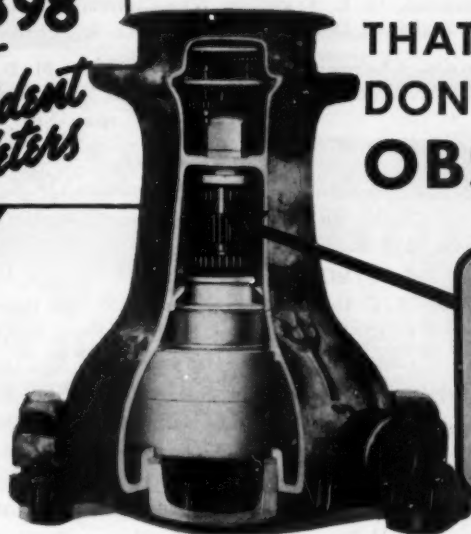
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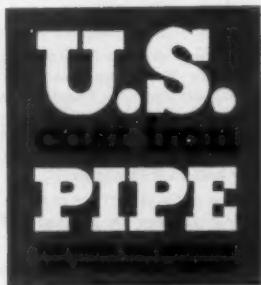
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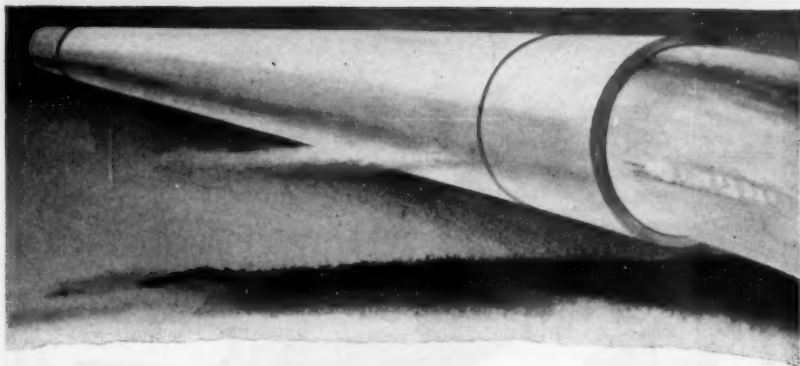


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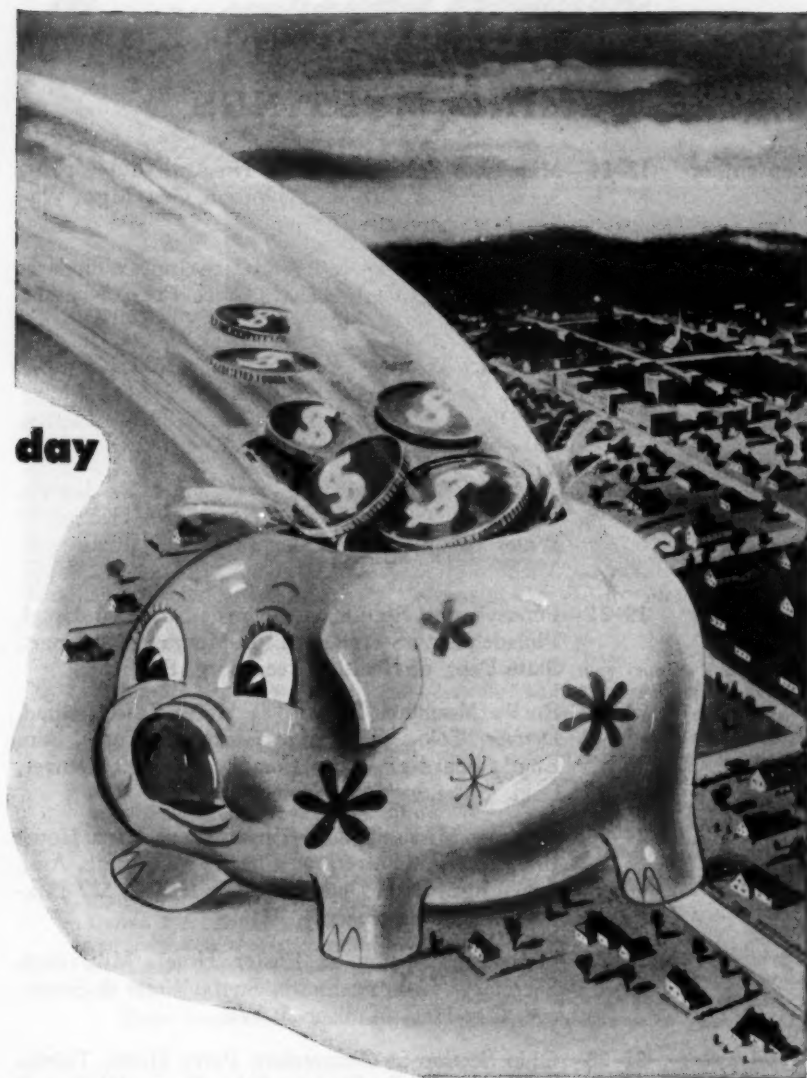
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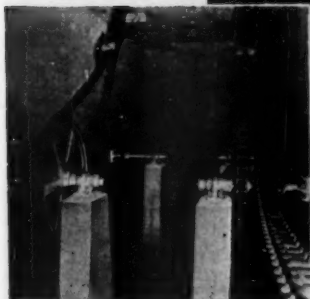
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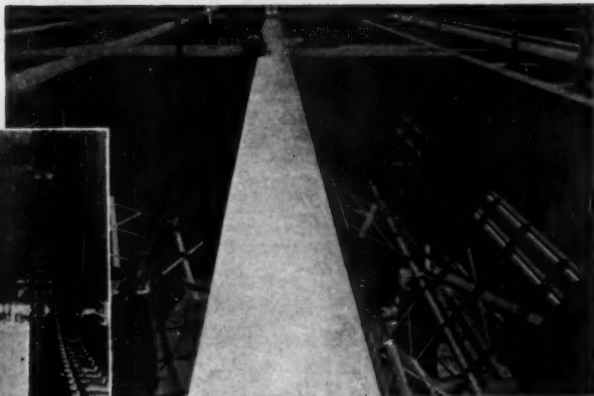
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(Continued on page 82)

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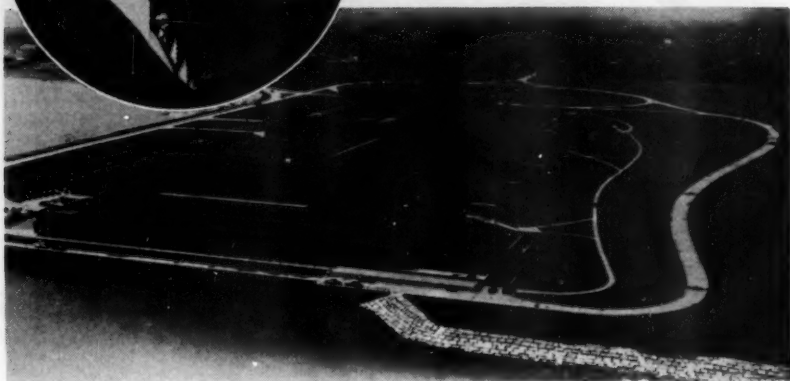
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August 1951

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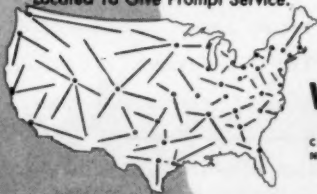
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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 43 • AUGUST 1951 • NO. 8

Water Use in Industry

By Roy R. Green

A paper presented on May 3, 1951, at the Annual Conference, Miami, by Roy R. Green, Agricultural Economist, National Assn. of Manufacturers, New York.

WATER is virtually the lifeblood of agriculture, industry and all human existence, and, although agriculture is the primary guardian of the land that is the reservoir of our water resources, the uses to which these resources are put extend far beyond purely agrarian interests. This fact has considerable bearing upon present and future efforts to develop and conserve the nation's water resources.

Water conservation, like soil conservation, basically involves the development and most efficient use of existing resources in order to increase the extent to which their use can benefit an ever-growing society. Physical and financial measures are therefore necessary both to increase the volume of water captured for direct use and to enable the use of the presently available water in the most efficient manner possible. The U.S. has now developed to the extent that these two actions must be carried out almost simultaneously. It would be a hazard to the na-

tion's prosperity and even security to halt the development of new water resources and depend entirely upon increasing the efficiency of use of existing resources. Conversely, it would be hazardous to halt the development of measures providing for more efficient use of present sources and depend upon new ones to replace those that become depleted.

Industry is a heavy user, rather than a principal guardian, of the nation's water resources. The manner in which industry utilizes water thus must have an important bearing on the national problem of water conservation, and what also may become a national water development and use policy.

This article attempts to highlight the findings of a recently completed study of water use practices in industry. While no attempt will be made to relate these practices to any proposed national water policy, the original study presents basic data on industrial water use from which it is possible to draw con-

clusions useful to the formulation of a national water policy, as well as a water policy for industry itself.

Background of the Problem

Early in 1950 the author investigated means of determining what constitutes current water use practices in American industry. The ultimate object of this study was to assemble information on the volume and utilization of water by industry, upon which to build recommendations for further industrial

pulp and paper, petroleum and chemicals, available nation-wide data on the subject were extremely limited. Other means of securing the information were therefore investigated.

The result of these investigations, made jointly by The Conservation Foundation and the National Association of Manufacturers, was the conclusion that a mail questionnaire survey of the NAM member companies presented the most practical source of factual data on the subject. A question-

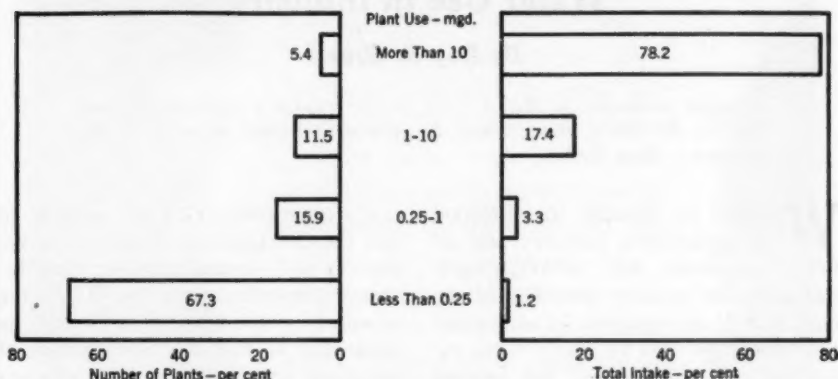


Fig. 1. Plant Classification by Water Use

A comparison is made between the distribution of the number of plants and the distribution of the total water intake. A relationship is also shown between the number of plants and the unit volume consumption.

conservation and development of water. The investigation was begun on the premise that until some accurate index of water use practices employed nationally by industry was available, it would not be possible to develop a sound and practical national water policy for American industry, a sound water policy for the nation as a whole.

Research was therefore undertaken to secure data that would yield a composite picture of industrial water use practices on a national scale. Except for a few individual industries such as

naire was subsequently drawn up and mailed to the 15,000 NAM member concerns. About 3,000 of the returned questionnaires were tabulated and analyzed. A detailed report of the survey (1) is now available.

Water Intake in Industry

The total water consumption of the U.S. is believed to be approximately 100-150 bil.gal. per day (bgd.). Estimates of the proportion used daily by industry vary from 10 to 25 bgd.—never more than one-fourth of the total.

The present study is based on approximately 3,000 industrial plants in the nation having an aggregate water intake of about 8 bgd. (1). Since these 3,000 plants represent only about 1.3 per cent of the total number of industrial plants in the nation,* it is quite possible that American industry uses far more than 10-15 bgd. It also ap-

lation of a national as well as an industrial water policy. The study provided rather specific answers, on both national and regional bases, to some major questions about industrial use of water.

It is significant that a distinct pattern of water intake appears to exist between the small and large water-

TABLE 1
Distribution of Plants in Each Industry According to Water Use

Industry	No. of Plants	Proportion of All Plants in Industry (Water Intake in 1,000-gpd. Units)*				
		Less than 50	50 to 250	250 to 1,000	1,000 to 10,000	10,000 and over
		<i>per cent</i>				
Apparel and textiles	256	43	24	17	14	2
Autos and aircraft	112	31	23	31	12	3
Chemicals and drugs	220	34	20	21	19	6
Electrical†	148	40	24	18	4	14
Foods, beverages and tobacco	367	40	22	17	16	6
Iron and steel	344	50	20	17	8	6
Leather	37	43	24	19	5	8
Lumber and furniture	147	72	14	7	5	1
Machinery and tools	524	60	21	12	5	1
Nonferrous metals	134	42	25	12	18	4
Optical, medical, scientific supplies	42	57	19	14	7	2
Paper and pulp	164	34	14	10	25	18
Petroleum products	53	19	9	15	34	23
Plastics	27	41	30	18	4	7
Stone and glass	217	48	18	22	9	4
Toys, novelties, sport goods	17	53	24	18	6	..
Miscellaneous and unspecified	248	45	25	13	12	4
ALL PLANTS COMBINED	3,057	46	21	16	12	5

* Items do not add to exactly 100 per cent for each industry because of rounding.

† Power generating and equipment manufacturing combined.

pears likely that the estimate of 25 bgd. is conservative.

It is nevertheless obvious that the water use practices governing the utilization of at least one-fourth of the nation's developed water resources must be a major consideration in the formu-

* The 1947 Census of Manufacturers listed 240,881 manufacturing plants.

using industrial plants. As shown in Fig. 1, most of the reporting plants take in relatively small amounts of water, while comparatively few plants account for the largest percentage of the total water intake measured (approximately 8 bgd.). The information suggests very strongly that future studies of industrial water problems should con-

centrate on the relatively few large water users.

It is evident that the large users of water are concentrated mainly in three types of industries. As shown in Table 1, only in the electrical, paper and pulp and petroleum industries are there any significant numbers of plants reporting a water intake of over 10 mgd. Other relatively heavy users appear in the 1-10 mgd. class. They are textiles, autos and aircraft, chemicals and drugs, foods and metals. The survey disclosed 48 plants of various kinds that reported an intake of 50 mgd. or more.

Industrial Growth and Water Use

The large water users are, themselves, generally large or extensive types of manufacturing operations. They are either basic industries, or are closely allied to basic industries. Thus, as the nation's industrial plant expanded over the last decade, with production almost doubling from 1939 to 1949, it has been assumed that the use of water, particularly by basic industries, has expanded proportionately. Except for a few industries, however, this belief was not based on known facts. The present study offers some indication of the effect of industrial growth on water use, as shown in Table 2.

The survey records an average increase in water intake of 36 per cent from 1939 to 1949. This figure, however, cannot be taken as representative of all American industry, because the survey could not reflect the increase in intake of plants established between 1939 and 1949. In the plants covered by the study there was a distinct relationship between the scale of plant operations and the increase in water intake. Table 2 indicates that, as the proportional increase (1939-1949) in water intake rises, the proportional in-

TABLE 2

Change in Water Intake, 1939 to 1949, and Average Change in Employment in Each Class

Water Intake Change (1939 to 1949) per cent	No. of Plants	Median Employment Change (1939 to 1949) per cent
<i>Decrease</i>		
75-100	13	0
50-74	31	+5
40-49	16	-2
30-39	40	0
20-29	57	0
10-19	61	0
1-9	55	+3
<i>No Change</i>	306	0
<i>Increase</i>		
1-9	94	+18
10-19	142	+20
20-29	180	+27
30-39	159	+27
40-49	95	+34
50-74	241	+46
75-99	106	+60
100-199	344	+64
200 and over	259	+134
TOTAL	2,537*	+33

* Exceeds total of column, since some plants did not report change in water intake.

crease (median) in number of employees also rises. Employment increased about 33 per cent for all plants combined. This rise is not appreciably different from the reported increase in water intake of 36 per cent.

There appears to be a clear tendency for the rate of growth in industrial water use to increase proportionately with the size of the industrial plant.

Water Use Practices

One of the most significant findings was the great number of uses to which water is put. It appears that the use of water by small and average size industrial water consumers differs considerably from that of the large plants.

Figure 2 shows that among the large water users, cooling is by far the most important of the several uses. The use of only about one-third of the intake for processing is somewhat surprising in view of the many somewhat bulky products made by many of these large industries.

Among the smaller users, it is clear that water for cooling is much less important. In this group, water for processing and for sanitary and service purposes is a great deal more significant.

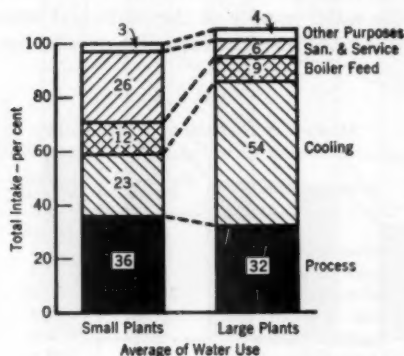


Fig. 2. Industrial Use of Water

Five major industrial uses of water are given. The relative quantities for each use are compared for large and small plants. The total for large plants exceeds 100 per cent because of the inclusion of reference to reused water in some replies.

As shown earlier, the large water-using industries account for the largest proportion of the total water use in industry. The immediate concern with water use in industry should therefore be directed principally toward the utilization practices followed by the large users. If further economy is desired in the industrial use of water, it is obviously in this group of industries that most can be accomplished in the shortest space of time.

Water Treatment

Water quality is of foremost importance in such industries as chemicals, textiles, and plastics. Because there was believed to be a widespread difficulty in securing water of proper quality, the recent survey attempted to discover the extent to which manufacturing plants applied some form of treatment to water. The results of this inquiry are shown in Fig. 3.

Facilities for treating water are much more common in large plants than in

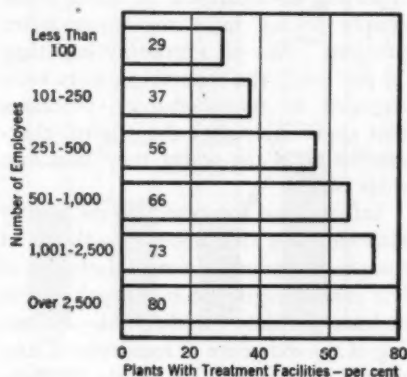


Fig. 3. Plant Water Treating Facilities

The proportion of plants with treatment facilities increases with the size of the plants.

small plants. Approximately 80 per cent of the former reported they now have water treatment facilities. Approximately 30 per cent of the latter reported such equipment. As the volume of water use increases, it becomes more economical to develop private methods of treatment than to purchase treated water of satisfactory quality.

Waste Water Treatment

The prominence of water pollution in current discussions made it worth-

while to secure some data on the extent to which industrial waste water is treated before disposal. It was found that the large plants engage in this practice to a far greater extent than the small ones. Almost half the large plants reported that they treated waste water in some way before disposing of it, while more than 80 per cent of the small plants reported no treatment of any kind.

These figures do not, however, tell the whole story. It is obvious that many of the plants, small and large, reporting no treatment of waste water simply do not have any waste water problem. Not all (probably less than 50 per cent) the reporting plants were engaged in manufacturing processes that appreciably alter the original characteristics of the water they take into their plants.

Information furnished by the survey also indicates that about two-thirds of the plants having a water discharge of less than 1 mgd. use municipal sewers at least partially for disposal. Knowing of the existence of hundreds of municipal sewage treating plants throughout the nation, it is safe to assume that much of the waste water discharge of small- to medium-size plants eventually receives treatment before being released into streams and underground water channels (Table 3).

Plant Expansion and Water Supply

From the standpoint of industrial expansion and decentralization, the survey disclosed significant information on the possibilities of treating water prior to releasing it. Such action, taken on a regional basis, would conserve available supplies. Plant managers were asked to give their opinion on the potentiality for further industrial expansion in particular areas, in view of the available water supplies in those

areas. This shift of interest from the past to the future naturally involves a shift from recorded fact to opinion. It is nevertheless of considerable value to determine what the industrialists believe the possibilities are for a future increase in industrial water use in definite areas. The replies to this inquiry are summarized in Fig. 4.

The most striking feature of this tabulation is the large number of non-committal replies. Almost 40 per cent of the 3,000 plants surveyed indicated that management was not aware whether the water supply of the particular area was being used at capacity, or whether

TABLE 3
Methods of Disposal of Waste Water

Method of Disposal	Number of Plants	Proportion of Total*
		<i>per cent</i>
River	857	28.1
Lake	73	2.4
Municipal sewers	2,104	69.0
Bay or ocean	85	2.8
Earthen basins	215	7.0
Other methods	179	5.9

* A total of 3,049 plants reported the methods used in disposing of water, and the percentages are based on this figure. They add up to more than 100 per cent, since some plants use more than one method.

it could support a few, many or unlimited additional industrial plants.

It appears that those people who are most immediately concerned with the problem of conserving the nation's water resources have not secured the broad support of one of the heavy users of that resource. A negative result of 40 per cent clearly demonstrates that many industrialists are not aware of the water supply conditions in their own communities, or, at least, that they are not sufficiently informed to venture quotable opinion.

Industrialists of the East South Central States and the West South Cen-

tral States seemed to be the most optimistic about the extent to which their respective water supplies would support additional plants, while the people in the Mountain States were the least so. It is noteworthy that in the last region, not one reply reported an unlimited number of additional plants to be possible. These regions also produced a

of pollution in their areas is improving, growing worse or remaining the same. The answers exhibited a wide variety of opinions. Most of the plants believed that pollution is not changing in either direction—possibly because they were not sufficiently aware of the local situation to reach any other conclusion. More, however, were of the opinion

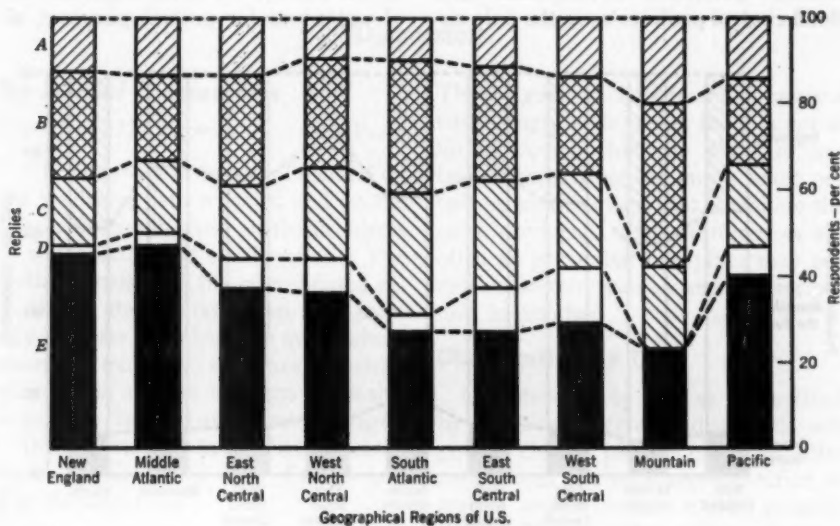


Fig. 4. Opinions on Potential Expansions

Opinions on the possibilities of expanding the industrial use of water in the various geographical regions of the U.S. show sectional variations.

Key
 A—Local sources at capacity.
 B—Few additional plants possible.
 C—Many additional plants possible.
 D—Unlimited additional plants possible.
 E—No opinion.

relatively small number of indefinite answers, indicating industrialists are probably more conscious of water problems than those in other regions.

Trend of Water Pollution

Another question of interest is the national trend in water pollution. Plant managers in each geographical region were asked whether the status

that the status of pollution was improving than believed that it was growing worse. This information is presented in Fig. 5 on a regional basis.

Water Conservation Projects

An interesting sidelight on the survey was the discovery that industrialists seem to have very little knowledge of federal, state, county or municipal con-

servation activities affecting water resources in their respective areas. Industrial plant managers were asked to indicate whether such activities as valley authorities, state watershed development and irrigation projects were either planned or in operation in their areas. Very few reported that they knew of any such activity. Governmental watershed development and flood control projects were the only ac-

2. The relatively few industrial plants that use exceptionally large amounts of water account for the largest part of the aggregate industrial use.

3. The increase in the scale of industrial operations over the past ten years has been partly responsible for the increased use of water by industry.

4. Among all the industrial plants in the survey, the most important use of water was for process purposes, al-

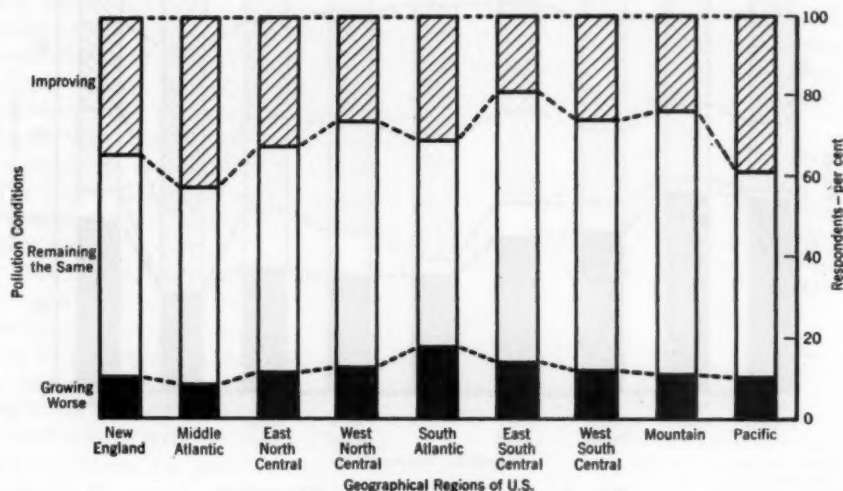


Fig. 5. Pollution Trends

Proportion of opinions on pollution trends are given by geographical regions throughout the U.S.

tivities known to 10 per cent of the managers. This reaction also suggests that public support for both public and private water conservation projects has missed the backing, and even the thinking, of many sound and practical community leaders.

Summary

The following features of water use in industry are considered outstanding:

1. Approximately 25 per cent of the nation's daily water use is in industry.

though cooling water is most important in the large water-using plants.

5. Approximately 50 per cent of the industrial plants covered by the survey have their own facilities for water treatment. More large plants than small ones have such facilities.

6. A greater proportion of large than of small plants treats waste water. Small plants tend to dispose of waste waters through municipal sewers.

7. A great diversity characterizes the opinions of industrialists on the po-

tentialities for expanding industrial water use in their immediate localities.

8. Most industrialists believe that the status of pollution in their areas is either improving or remaining the same, although, in some localities, a fairly large number report that pollution is growing worse.

9. Most industrialists have little knowledge of federal, state, local, or municipal water conservation projects that might affect their water resources.

Reference

1. Water in Industry. National Assn. of Manufacturers & Conservation Foundation, New York (1950).

Discussion

By Daniel J. Saunders

Vice-Pres., The Permutit Co., New York.

The author is to be complimented on the wealth of data revealed and on the broad viewpoint given on the problems of water usage and conservation. The writer agrees with the often quoted remark that there is no nation-wide scarcity of water, but there are areas where shortages exist, and there are industrial plants that cannot undergo extensive expansion because of these shortages.

It was gratifying to see that industrial water requirements were divided into five classifications:

- [1] Process water
- [2] Cooling water
- [3] Boiler feedwater
- [4] Sanitary and service water
- [5] Water for other purposes.

Most tables of industrial water requirements heretofore published give only a single figure for each industry based on the total water intake per unit of production. When only a single factor is used, the completely misleading impression is given that every industrial plant producing a particular product uses exactly the same amount of water per unit. Instead, a series of figures on water use, determined by surveys of a number of plants in a particular industry, should be given.

These figures will be found to cover a surprisingly wide range, for it is not at all uncommon for one plant to use two or three times as much water per unit as another plant that is making the same products. These differences are often so great that one plant may use more than ten times as much water per unit as another.

Classification by Use

Classification by use, as exemplified by the five categories discussed, will give a clearer picture of water utilization than any total representation of water requirements could possibly show. This practice will be of great value to industry by indicating more specifically the areas in which economies can be effected. If the operators of Plant A see that Plant B uses the same amount of water for boiler feed, cooling, sanitation and service, and other purposes, but only 20 per cent as much process water per unit of the same product, they are going to be very much interested in learning how Plant B accomplishes this saving. If Plant A's water resources are not particularly abundant and plant expansions are under consideration, this information will be of particular importance.

The author points out, that for plants using less than 10 mgd., the data

showed that 59 per cent of the total water intake was used as cooling and process waters (36 per cent for process and 23 per cent for cooling). In plants using more than 10 mgd., 86 per cent of the total water requirements was for cooling and process waters (54 per cent for cooling and 32 per cent for process). It is therefore evident that economies in water intake can be effected most easily by modifying process and cooling practices.

Reuse

There are many process waters, especially as used by large industries, which lend themselves to treatment, recovery and reuse by means of a "closed system." Such systems can frequently treat, recover and use again even more than 80 per cent of their process water. Reusable suspended and solid materials, as well as valuable heat units, may also be recovered by treatment of the used process waters, although the separated solids may sometimes be of no further use and necessitate disposal by burning, lagooning or other means.

Whether or not reuse of cooling water is necessary or advisable depends upon several factors, which may be ascertained by a survey. If the plant is located at tidewater, and sea water is used for cooling purposes, an inexhaustible supply is obviously available. Since such water requires little treatment, except intermittent chlorination, recovery and reuse are both unnecessary and uneconomical. With abundant surface supplies which require little or no treatment to use for cooling purposes, recovery is likewise unnecessary. The water may be used once for cooling purposes and then returned to the river or lake from which it was drawn.

Ground waters, such as deep well waters, are often preferred for cooling because of their even temperature. Whether or not such waters are to be recovered and reused depends upon a number of factors, among which are the composition of the water and the abundance of supply. If the water requires treatment—most ground waters and many surface waters do—and if conservation is advisable, a survey will indicate what methods of treatment and handling are best.

In some industrial plants, depending on heat balances and other factors, the cooling water is first softened and then used for cooling, sometimes in two or more stages. After this operation, the greater part or even all of the water is used for boiler feed or other purposes. To prevent scale formation on the metal surface of heat transfer equipment, the bicarbonate content only is lowered (usually by treatment with lime or sulfuric acid).

Plant Individuality

Each plant, of course, requires an individual study, for each presents individual problems. Methods of water recovery and reuse that are applicable in one plant are not necessarily applicable in another. In a host of industrial plants, however, studies of water usages will prove very profitable by showing where large economies can be effected by treatment and reuse of a large proportion of the total water intake.

By Edward B. Showell

Eng. Service Div., E. I. du Pont de Nemours & Co., Wilmington, Del.

The Conservation Foundation and the National Assn. of Manufacturers, upon whose survey the author's paper

is based, did a thorough job of canvassing industry for answers to their questionnaire. The writer can vouch for the integrity of the response from his company as he had the opportunity to observe the care that was exercised by the various industrial departments to obtain factual information for the answers.

Discussion of Responses

It is stated that the electrical and petroleum industries, as well as some others, are large users. It should be pointed out, however, that their use is for cooling, and therefore a minimum of treatment is required. Also, the better quality water furnished by municipalities is not necessary for this operation.

It is mentioned that the large users obtain water from their own facilities, but it should be observed that large industries are usually located out of town, beyond the city's mains. The cost of the water is therefore less when obtained and purified by the industry than when purchased from the city. Industry also uses different qualities of water, not only in different factories, but for different uses in the same factory. It is therefore often necessary for even smaller industrial water users to require further purification and treatment of the city water supply, in order to meet quality control requirements for the products that are manufactured.

The answers to the questionnaire on waste water treatment referred only to treatment. For that reason, the reduction in pollution accomplished by industry by recovery of materials, over the past few years, is not included. This practice often accounts for a considerably greater reduction in pollution

than does actual treatment. Industry strives first to reduce pollution by reclaiming materials from waste water, rather than by following orthodox treatment methods. Some savings can thereby be made to offset the costs of the reclamation investment and operation.

The questionnaire did not appear to bring out any plans industry might have to conserve water, if the institution of conservation projects becomes necessary because of inadequacy of future supply or increased expenses. There are numerous methods now known to reduce water use, and most of the large industrial users are aware of them. Many are actually reducing use. The smaller water users, however, are unaware of current conservation methods. Savings could be made by reuse and reclamation if studies were conducted to determine whether or not present use is excessive.

Industrial water users tend to give very little consideration to the question of the possible effects of future plant expansions until an actual shortage occurs. It is therefore not surprising that ignorance or indifference appears so prevalent in the responses to the questions on this topic. It is also evident from the data that those persons knowing most about the problem are in sections of the country where water is scarce.

Discussion of Summary

It is stated that the increase in the scale of industrial operations over the past ten years has been partly responsible for the increase in the intake of water by industry. That conclusion is correct, but there are also new industries, unknown ten years ago, which use water.

It is also stated that most industrialists believe that the status of pollution in their respective areas is either improving or remaining the same. This attitude is probably general at the moment. It is known, however, that municipal sewage treatment in some of the larger population centers is in either the planning or construction stage, and the full benefits will therefore not be evident until the dis-

posal plants have been operating for some time.

It is hoped that the Conservation Foundation and the National Association of Manufacturers will circulate another questionnaire several years from now to determine what progress has been made in the categories investigated. Perhaps some additional questions might be added to increase the scope of the study.

A.W.W.A. Statement of Policy on Fluoridation

The following statement of policy on fluoridation of public water supplies was adopted by the A.W.W.A. Board of Directors on April 29, 1951.

Two years ago (June 1949) in Convention in Chicago, the American Water Works Association adopted by resolution, this statement of policy on the fluoridation of public water supplies:

In communities where a strong public demand has developed and the procedure has the full approval of the local medical and dental societies, the local and state health authorities and others responsible for the communal health, water departments or companies may properly participate in a program of fluoridation of public water supplies.

The past two years have shown this position to be sound. It is now reaffirmed.

Recommendations for fluoridation are the prerogatives of the dental, medical and public health groups. When the proper authorities approve the treatment, it then becomes the function of the water works utility and industry to follow through willingly and intelligently where proper controls are assured.

Residential Water Use and Family Income

By Bernt O. Larson and H. E. Hudson Jr.

A paper presented on May 3, 1951, at the Annual Conference, Miami, by Bernt O. Larson, Assoc. Engr., Eng. Subdiv., State Water Survey Div.; Assoc. Prof., College of Eng., Univ. of Illinois, Urbana, Ill., and H. E. Hudson Jr., State Water Survey Div., Urbana, Ill.

AT a time when many communities in the United States are suffering from water shortages, a study of actual water use requirements seems appropriate. Excessive unaccounted-for water and water shortages have even been experienced simultaneously in some communities.

Per capita water consumption is the usual basis of comparison for the rate of consumption between different cities and towns, but such a comparison requires accurate data.

Per capita use is most commonly taken as the total of water supplied divided by the population served. The per capita pumpage for the entire state of Illinois, as of January 1, 1948, was computed to be 186 gpcd. If Chicago and connected suburbs are excluded, this figure drops to a mean of 88 gpcd., with individual cities as low as 8 and as high as 220 gpcd. This is gross per capita pumpage, however, and for comparisons of daily per capita use in cities and towns includes too many variables to allow tracing any detailed relationships.

Nearly all attempts to correlate water use have related the gross daily per capita pumpage with population. This article proceeds by classifying the actual water sold into the various categories: residential, commercial, indus-

trial, public, and loss and waste. When the data are so taken for basic unit uses, a better comparison becomes possible.

To collect data on metered use, thirteen Illinois communities (some of them groups of cities) were visited. The information gathered was separated into use categories. Dependable data from two other communities, "N" and "O," were obtained by correspondence and were used to check the curve that was plotted from the data obtained at the communities visited. With these facts available, a correlation between the use of residential water and estimated net family income has been found. This correlation succeeded where attempts to relate domestic or residential use and population factors failed.

One attempt to relate the gross daily per capita pumpage and the size of small Illinois communities using ground water is shown on Fig. 1. Each point represents the gross daily per capita pumpage in an Illinois community. These data on total ground water production were obtained, for another study now in progress, by engineers of the Illinois State Water Survey in visits made to every incorporated town and city of Illinois which use wells as a source of supply.

Classification of Uses

Five categories were used for sorting the data: domestic use, commercial use, industrial use, public use, and loss and waste. Domestic use was taken as that water purchased for the family dwelling. The definition of a commercial user varies somewhat from city to

street sprinkling, fountains, parks, fire-fighting and other such purposes. Lost and wasted water sometimes amounts to more than is actually used for all other purposes. Unaccounted-for water (loss and waste) should not be more than 20 per cent of the total amount metered, or estimated to be pumped from the source of supply.

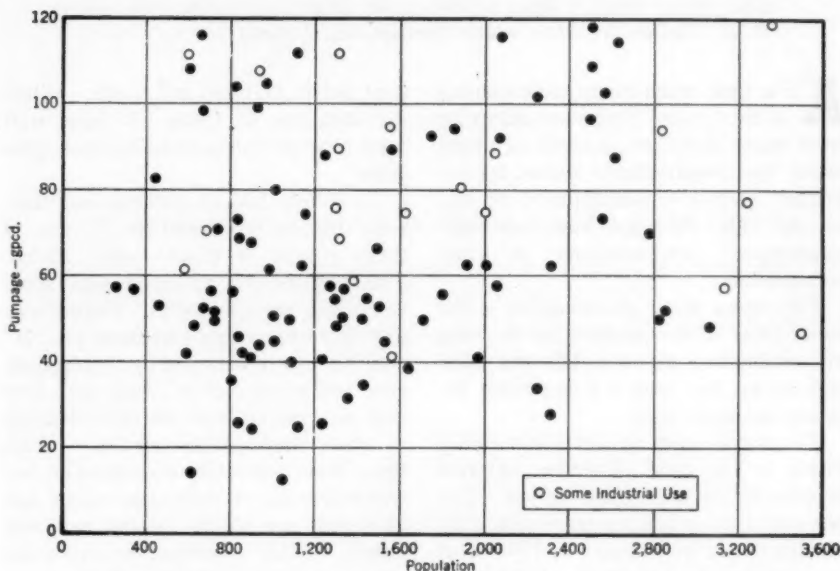


Fig. 1. Per Capita Production in Illinois Communities During 1947

An attempt is made to relate the gross daily per capita pumpage to the size of small Illinois communities that use ground water.

city, but generally it includes stores, hotels, local bakeries, dairies and laundries. Typical industrial users would be manufacturers, railroads or canneries. Public use in a city having a municipally owned and operated system is quite often not metered, and may be considered to be free or unaccounted-for water. A private water company will usually meter or estimate the use of water for public buildings,

Factors that may affect the rate of water consumption are numerous. Some of them are: size of the community, geographical location, variations within the community, standards of living of the consumers, quantity of the supply, quality, water rates, existence of sewers, distribution system pressure, the age of the water works system and whether or not meters are used.

TABLE 1
Per Capita Water Consumption in Illinois Cities

City	Corrected Resid. Accts.	Consumption—gpcd.					Unaccounted- for Water		Total Prod. gpcd.	Qtrly. Resid. Cost per Acct.	Calculated Qtrly. Resid. Cost for Eq. Use
		Resid.	Coml.	Ind.	Munic.	Sales to Other Water Utils.					
							gpcd.*	per cent			
A	10,420	39.0	8.8	16.0	2.0	1.1	9.9	13.0	76.0	\$4.25	\$4.25
B	6,861	39.0	7.4	20.0	0.02		17.5	20.1	83.9	4.83	4.83
C	1,773	24.0 30.5*	13.0	19.6	—		79.0	58.0	135.6	3.75	6.10
D	4,218	24.3	27.3	26.9	2.0		16.2	16.7	96.8	5.85	10.90
E	160	21.2	3.7	15.5	—		—	—	56.0	11.85	21.00
F	1,681	31.0	19.6	11.3	—		12.2	16.5	74.1	5.25	6.60
G	1,691	31.4	18.9	35.0	0.5		14.4	14.4	100.2	4.56	5.75
H	389	25.8	12.8	0.0	—		6.2	13.8	44.8	3.00	4.50
I	2,511	52.3	3.2	0.0	—		21.2	27.6	76.6	7.07	5.28
J	2,434	51.5	13.0	0.0	—		36.4	36.1	100.9	—	—
K	226	28.7	4.3	17.2	—		—	—	—	4.86	6.63
L	1,215	46.3	23.5	92.9	5.8		37.4	18.1	205.9	5.62	4.77
M	35,187	27.3	19.7	126.3	13.3		31.2	13.1	237.7	3.65†	5.22
N	2,020	36.7	16.2	8.8	5.1	50.4	20.2	14.6	137.4	—	—
O	4,881	28.4	12.5	77.9	18.5		27.5	16.6	165.8	—	—

* Average of 2 metered districts.

† \$3.75 minimum.

Key

Surface water supply represented by (S); well water supply represented by (W)

A—College community (W)
 B—County seat, light industry (W)
 C—County seat (W)
 D—Marketing center (S)
 E—Good rural community, excellent agricultural region, no sewers (W)
 F—County seat, marketing center (W)
 G—County seat, oil production center, agriculture, trading center (S)

H—Not progressive (W)
 I—Suburban residential (W)
 J—Residential, light commercial (W)
 K—Rural, new water works, few sewer connections (W)
 L—Good residential, light industry (W)
 M—Heavy industrial, railroad center (S)
 N—Residential, in good agricultural area (S)
 O—Industrial, coal mining region (S)

Procedure Used

A list of cities known to keep the necessary records was compiled. These communities employed universal metering of their services, and also metered the actual pumpage. Consideration was then given to geographical location and the utilities studied were chosen to provide the most complete state coverage possible. A diverse population range and use of various sources

of supply were deemed necessary. The primary use for which water was sold in the various cities was also considered. One city, for example, was selected because it was wholly residential; another, because of its heavy industrial requirements. The age of the water utility to be selected was also considered. The cities finally used comprised a reasonably good sample of the variety of conditions found throughout the state.

Many cities were eliminated from the study after visits had revealed the lack of accurate or complete records. All the privately operated utilities visited had excellent and complete records of pumpage, plant use, quantities sold, unaccounted-for water and the costs of operation. A number of the publicly owned utilities had just as complete and accurate records.

A few of the communities had multi-family dwelling units with single service meters, but the number of such installations was small. Where such meters were found, the number of family units was obtained and an appropriate correction was made to the actual total of residential accounts.

The data for each of the cities visited appear in summary form in Table I. In computing the daily per capita consumption for the various accounts—residential, commercial, industrial and public—the total average daily quantity sold for each of these categories was divided by the total number of corrected residential accounts. This quotient was in turn divided by 3.6 persons per family* to obtain the daily per capita consumption.

When the amount used commercially was obtained and then computed to a daily per capita basis, it was seen that there was considerable variation, ranging from a minimum of 3.2 to 27.3 gpcd. Most of the utilities classified their accounts much the same way. In several communities, it was necessary to go through the records and do the actual classification, as only the total amount of water used or sold was tabulated. An account was generally designated as commercial if the user operated a business establishment that served the

community, such as a grocery or other store, gas station or bakery. If the user produced or manufactured some product that would be sold elsewhere, and used water in its manufacture, the user was ordinarily classified as an industrial account.

Discussion

It can be seen from Table I that there is little correlation between the residential daily per capita use and the population of the community served by the utility. As city after city was visited, it became increasingly clear that a good correlation between daily per capita use and population of the community served was impossible without considering additional factors.

Residential use ranged from a low of 21.2 to a high of 52.3 gpcd. With but one exception, the highest values were for those cities located in the more prosperous part of Illinois. The lowest values were for those cities in the less prosperous part of the state, and the middle values were geographically distributed in the area that separates these two regions.

Another factor governing use might be water rates. The cost of water per account was recalculated on a basis of equal use in each community, as shown in Table I. No correlation between rates and use, however, was apparent.

Other factors that might cause variations in per capita use—such as quantity and quality of supply available, the existence of sewers, pressure and age of the distribution system and the use of meters—were considered, but, with only a single exception, they seemed of little importance. Community "E" was selected because the utility was one of the newest of those having metered services. A municipal sanitary sewer system had been placed in operation in

* Population per household in Illinois in 1940 (1). It was assumed that a residential account is the same as a household.

February 1949, but at the time of the visit only 45 of the 178 water services had been connected to it. When all the water users are connected to this system, the per capita use will undoubtedly increase.

A small rural community, "K," is in the northern part of the state. It is comparable in size and general character with "E." The principal difference is in the age of the two utilities.

TABLE 2

Estimated Average Annual Effective Buying Income per Family (2)

Community	Income		Increase Since 1940 per cent
	1940	1947-48 Avg.	
A	\$2,815	\$5,550	95.5
B	2,451	5,200	112.0
C	1,746*	4,050	132.0
D	1,555	2,750	77.0
E	1,091*	2,100	92.5
F	1,532*	3,600	135.0
G	1,428*	3,450	141.0
H	1,428*	3,450	141.0
I	3,198†	7,500	137.0
J	2,546†	6,400	151.0
K	2,825*	5,300	87.6
L	3,150†	5,700	81.0
M	2,030	4,500	121.0
N		4,650(?)	—
O	2,209	4,978	125.0

* County data.

† Comparable nearby city.

Although the village has no sanitary sewer system, many of the homes have their own septic tanks. Residential use at "K" was higher than in five of the communities served by sewer systems.

As none of the above factors were found to govern the use of water, there must be something else that does cause the variations that exist. The one remaining factor that might cause this variation is the standard of living.

Effect of Family Income

In *Sales Management* magazine's annual "Survey of Buying Power" (2) can be found estimates of average net effective buying income or a per-family basis for states and larger cities. This information, however, was not available for all communities included in the study, and therefore a few cities of similar character and geographical location (some county figures) were

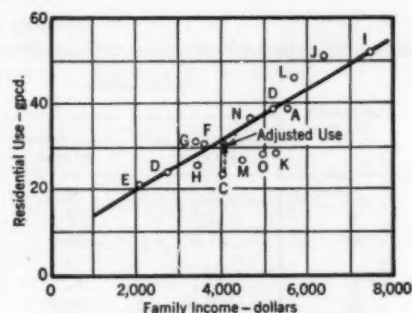


Fig. 2. Residential Use and Family Income

A good, positive correlation is shown between residential water use and effective buying income. An estimated adjustment was made for the per capita consumption in Community "C" because of faulty data obtained by computing incomplete meter readings.

substituted. This information is presented in Table 2.

When daily per capita residential use was plotted against net effective buying income, a good correlation appeared, and can be seen in Fig. 2. Although a straight line can be drawn through several of the values, a number of points do not fit exactly. Detailed examination of some of these departures proves profitable. In Community "C" there are three residential meter zones. Two of them reveal resi-

dential use of 30.5 gpcd.—an excellent fit. The superintendent reports that the meters in the third zone are in need of repair. Consumption in that zone registered 15 gpcd., indicating serious underregistration. This conclusion is bolstered by the 58 per cent unaccounted-for water for the community as a whole.

In Community "M," there was a great industrial expansion during

cities when the war was terminated in 1945, there was a general increase for every community subsequently. Proportionally, however, Community "M" still showed the greatest increase in net effective buying income per family for the twelve years considered.

These higher wages do not necessarily parallel the actual standards of living. The people of this community are not investing in indoor baths or

TABLE 3
Sanitary Facilities (3)

Community	Homes Lacking:		Consumption Allowance for Complete Facility Installation		Total Consumption (Including Improvement Allowance) gpcd.
	Bath and Shower per cent	Flush Toilets per cent	Bath or Shower gpcd.	Flush Toilet gpcd.	
A	13.2	9.6	3.4	2.0	44.4
B	14.5	5.2	6.8	1.1	43.7
C	27.0	20.4	5.8	4.0	34.9
					41.3†
D	37.7	35.0	9.3	7.6	40.6
E	38.0*	29.0*	10.7	7.7	39.6
F	27.4	24.1	6.9	4.8	42.7
G	24.0	22.4	6.0	4.5	41.9
H	24.0*	22.4*	6.0	4.5	36.3
I	0.2	0.0	0.4	0.0	52.7
J	2.4	2.0	0.6	0.4	52.5
K	42.6*	38.6*	10.6	7.7	47.0
L	4.2	0.7	1.0	0.1	47.4
M	34.8	38.6	8.8	5.5	41.6
N	18.5	12.6	4.6	2.5	43.8
O	24.9	18.0	6.2	3.6	38.1

* Estimated.

† Average of accurately metered zones.

World War II, and family income increased greatly. The net effective buying income in one portion of the community had risen 150 per cent in 1944 since 1937. In two other parts of the community the income had approximately doubled since 1937. In "A," the increase was 87 per cent, while in "B," the increase was 50 per cent for the same period. Although there was a general decrease in income for all

showers and the usual standard sanitary facilities. A new car appears to have had more appeal. During the past decade, there has been a very small increase in residential water use, probably due only to the building of new homes in accordance with the approximately 25 per cent increase in the number of accounts, as residential water use has only increased 15 per cent. This situation is graphically repre-

sented in Fig. 3. The rise in income apparently failed to be followed promptly by increased water use in the home.

Effect of Sanitary Facilities

Sanitary facilities in the various communities are not at all standard. Some are almost completely served with showers or baths and indoor flush toilets, while others have relatively few of these modern facilities. Table 3 summarizes the available data on sanitary facilities.

To make use of the data in Table 3, it was necessary to make further assumptions. For homes with complete sanitary facilities, it was assumed that each person would require or use four toilet flushes per day, each of 5 gal. This would amount to 72 gpd. for each residential account. It was assumed that each person would require 25 gpd. of water for bath or shower, which is equivalent to 90 gpd. per residential account.* Considering the percentages of dwelling units without sanitary facilities to be applicable to the residential accounts that were served by each water utility, estimated increases in the average per capita consumption were computed.

The estimated values for daily consumption per capita for each city are plotted on Fig. 4. It can be seen that the correlation is better than in Fig. 2.

The value for Community "M" falls far below the original curve in Fig. 2, but when the corrections for sanitary facilities are applied, as shown in Fig. 4, the calculated use more nearly correlates with the other values along the curve.

* These values are rough, but compensate reasonably well for other residential uses not included specifically such as laundering, sprinkling, etc.

Community "H" shows a considerable departure from the curve in Fig. 4. This variance is believed to be due to two factors: [1] the income (estimated value) used is probably too high, and [2] the estimated values used to calculate the allowance for 100 per cent sanitary facilities are probably too low. The values used for "H" were those available for "G" because the two communities are similar, close to each other and no values for "H" were available.

Residential use at "J" is comparatively high. This is not surprising as the area is a residential suburb.

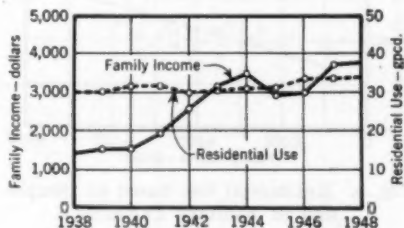


Fig. 3. Family Income and Residential Use for Community "M"

The trend in residential water consumption from 1938 to 1948 is related to the annual family income during the same period.

For Community "N," data obtained by correspondence were used to check the curve obtained from the values computed for those cities visited. On the basis of the average net effective buying income value for the city, but without correcting for sanitary facilities, it was predicted from Fig. 2 that the city would be found to be using 35 gpcd. for residential purposes. Calculations showed the city use to be 36.7 gpcd., a reasonable check. On the same basis, an estimated use of 36 gpcd. was predicted for Community

"O." The actual calculated value from available data showed a use of 28.4 gpcd., which was not a satisfactory check.

Community "O" is a much more industrialized city than "N," but it is similar in many respects to Community "M." Income alone does not indicate the standard of living of a community. Although the family income has increased rapidly, the people have neither invested their earnings in modern sanitary facilities nor become accustomed to the greater water use that seems

creases were higher than those for any other community with low per capita use as is shown in Table 2. It would appear that these two communities with low per capita use and with a rapid increase in income for this period have used a portion of their increased incomes for the luxuries rather than the necessities of life. Communities "I" and "J" showed higher income increases than "M" and "O" for the same period. Their per capita use (and standard of living), however, was already high, and the proportional increase in income is therefore not applicable to the same degree as it is for the two previously discussed communities.

Communities "F," "G" and "H" are not considered applicable since the only income values available were those for the county rather than the community.

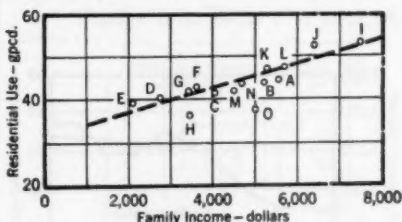


Fig. 4. Residential Use Based on Completion of Sanitary Facilities

The estimated daily per capita consumption for residential use is based upon the installation of a bath or shower and a flush toilet in every home in each community.

usually to accompany greater income. They apparently preferred gasoline to water.

If income values for cities alone are considered, certain quantitative conclusions can be drawn. Communities "A," "B," "I," "J" and "L" had relatively high income values as well as high per capita water use. Communities "D," "M" and "O" had much lower reported incomes as well as relatively low use. It therefore appears that prior income is a factor. Communities "M" and "O" with low incomes in 1940 showed increases by 1947-1948 that were nearly equal. These in-

Summary

Detailed data on water use were obtained from fifteen Illinois communities. The data were separated into five use categories: domestic or residential, commercial, industrial, public use, and loss and waste.

No correlation between population of community and water use was found. Uses varied as shown below.

Use	Consumption gpcd.
Residential	21.2- 52.3
Commercial	3.2- 27.3
Industrial	0-126.3
Public	Up to 18.5
Loss and Waste	Up to 79.0

There was an apparent relationship between family net effective buying income and residential use, with use ranging from about 10 gpcd. for low incomes to 52 gpcd. for high family incomes.

The income-use correlation was improved by making allowance for the status of sanitary facilities in each community.

There are indications that the standard of living of the community, taking into consideration prior as well as present income, is related to residential use.

Acknowledgment

This paper is condensed and revised from a thesis by Bernt O. Larson, entitled "Investigation of Per Capita Use of Water in Selected Illinois Cities" submitted to the Dept. of Civil

Eng., Univ. of Illinois. The data were gathered under sponsorship of the Illinois State Water Survey.

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Correction

In the paper "Water Policy as the Engineers See It" by Abel Wolman, which appeared in the June 1951 JOURNAL, a printer's error in placing a line confused the sense of one statement. On page 405, second column, the sentence beginning: "In a period of less than" should have continued: "twenty years, the ratio of benefit to cost has dwindled to minus two."

Considerations Involved in Adding Industrial Customers to Public Water Supply Systems

By Alfred O. Norris

A paper presented on February 8, 1951, at the Indiana Section Meeting, Indianapolis, by Alfred O. Norris, Exec. Vice-Pres., Indianapolis Water Co., Indianapolis, Ind.

THE arrival of a new industry in a well established community of moderate size poses a number of problems. Although such a community may formerly have received adequate service from a well operated water utility, with the new industry there will probably come a need for the development of previously unused sources.

A water utility should welcome a new industry to its area and attempt to work out the problem of adding the additional load to its system. An open-minded approach to the problem is required of both the industry and the utility, as well as a full and honest disclosure of all facts. Exaggerations and understatements for the purpose of persuasion should be avoided.

Early Conference Advisable

The industry, in considering the numerous problems of employee transportation, railroad facilities, land values, availability of power and other related matters may have overlooked the question of a water supply, and an early approach to this problem is therefore desirable. Knowledge of the availability of a water supply may influence the choice of the particular location for the new industry. If the industrial organization asks the water utility about the possibility of supplying its water requirements, a full and early

discussion of the problem has been facilitated.

The quantity of water that will be required should be determined accurately, as it is the only measure of the revenue the utility will receive. The flow rates at which the desired quantity of water will be taken must also be determined to learn what additional investment may be required. If this early stage of discussion is to govern, in any way, the location of the industry, the representative of the water utility should know what section of the distribution system can best meet the demands.

Utility's Attitude

In negotiations of this sort, the water utility representatives should indicate that they naturally want new business, but they must also make clear the limit of the expenditures that will be made in order to render the desired service, and thereby to obtain that business. This factor cannot be overstressed. When adding a relatively large customer to its system, the water utility must make certain that it will earn a good return not only in the pipeline and appurtenances needed to connect the new industry to existing lines, but also on the additions that will eventually be needed at its plant in the way of pumps, filters and other facili-

ties. The addition of such a customer may necessitate an immediate addition to plant facilities. If the revenue from one large customer is not sufficient to support its share of the required additional facilities, the utility is operating uneconomically.

Calculating Expected Costs

In developing a method of calculating expected costs, the utility should know what relationship its investment in pipelines or its investment in pipelines and services, has to its total investment in plant and property devoted to the service. Over the years, this relationship will probably remain fairly constant.

The Indianapolis Water Co. offers an excellent example of this relationship. Only pipelines are considered, as this company does not install services. The amount invested in pipelines in 1926 was 39.5 per cent of the total value of the plant, as shown on the books. This figure ranged between 38.4 and 40.9 per cent during the 15-year period ending with 1941. During 1942 the Geist Reservoir was constructed and the figure dropped to 35.8 per cent. Since that time, and particularly since the end of World War II, it gradually rose to a peak of 45.9 per cent at the end of 1949. If the contemplated program of plant improvements and additions is completed, it will be about 41.5 per cent at the end of this year. After a few more years the figure should again be about 40 per cent.

Operating Ratio

The operating ratio, or the percentage of operating revenues that are absorbed by operating expenses, is another important factor to be reckoned. It will vary, but a review of the experi-

ence over several years will suggest a fairly representative figure. For the sake of brevity and simplicity, 50 per cent is offered as a reasonable ratio.

Determining Fair Revenue

The two proportions developed above may be used by the utility to determine the revenue the new industry should provide on the cost of the main needed to furnish that industry with water. On the basis of the Indianapolis factor of 40 per cent as the amount invested in pipelines, the utility's system will eventually have to absorb not only the cost of the main to serve the new industry, but an additional $1\frac{1}{2}$ times as much in other facilities. The total investment will therefore be $2\frac{1}{2}$ times the cost of the main alone. The 50 per cent operating ratio indicates that only one-half of the revenue from the new industry will be available for return on $2\frac{1}{2}$ times the cost of the main to serve.

With 50 per cent of the revenue going to operating expenses, the desired return expressed in a percentage figure will have to be doubled. Then to earn the desired return on $2\frac{1}{2}$ times the cost of the main, the desired return will again have to be multiplied by $2\frac{1}{2}$. Taking these two multipliers ($2 \times 2\frac{1}{2}$) together, the figure five is developed. Assuming that 6 per cent is the desired return for the utility in question, the gross return on the main alone will have to be a dollar figure equal to 30 per cent (5×6 per cent) of the cost of the main.

This method of calculation seems quite reasonable. Certainly the utility has the responsibility of maintaining service to its existing customers and cannot risk jeopardizing its ability to do so by taking on an industry under any less favorable terms.

Since the desirable return may seem excessively high to the representative of the new industry, the utility representative will be required to explain thoroughly its position. To do this intelligently, he must have full command of all the facts. If a good selling job is done, the industry will realize that the utility already has responsibilities of long standing and, because of the very nature of its regulated business, must develop very conservatively.

An Alternative

If industrial representatives understand the water utility's position but are nevertheless unwilling to enter into an agreement to provide the gross return required by it, they have the possibility of developing a separate water supply. The water utility representative can be singularly helpful in developing this alternative. He should certainly bear no resentment in having failed to sell his original proposition to meet the industrial needs of the plant. He may be offering a product that, although in some respects superior to that needed by the industry, may lack key factors that can be found in a special supply developed by the industry for its sole use.

Offering Comparisons

For comparative purposes, the utility's representative can furnish data on the temperature range of the public supply, the hardness at different seasons of the year (if it varies), at what pressures it will be available and any other pertinent data on the character of the water. If he still feels that the business may be obtained on his terms, he can review the maintenance costs that an industrial plant manager might overlook. He may also cite the reliability of the service offered by his utility by calling attention to safety factors and reserves built into his property, and the long record of continuous service.

Maintenance costs and the value of continuously reliable service are two factors an industry sometimes overlooks in analyzing the cost of its private supply. If the cost and value of these two factors were properly asayed and added to the actual operating and carrying costs, the total might exceed the rates charged by the utility. Virtually the same problems are involved in producing the water by either method, with the single exception of the main connecting the industrial plant to the system of the utility.

Studies on Radioisotope Removal by Water Treatment Processes

By Rolf Eliassen, Warren J. Kaufman, John B. Nesbitt and Morton I. Goldman

A paper presented on May 1, 1951, at the Annual Conference, Miami, by Rolf Eliassen, Prof. of San. Eng., Warren J. Kaufman, John B. Nesbitt, Research Assts.; Sedgwick Labs. of San. Science, Dept. of Civ. and San. Eng., Massachusetts Inst. of Technology, Cambridge, Mass., and Morton I. Goldman, U.S. Pub. Health Service Environmental Health Center, Cincinnati, Ohio.

TO what extent does the probability of contamination of water supplies by radioactive substances constitute a problem today? What are the sources and nature of such contaminants? How effective are conventional treatment processes in bringing about their removal? These questions, and many others expressed by members of the water works profession, emphasize the need for a detailed, objective definition of the relationship of radioactive wastes to water supplies.

The studies reported in this paper constitute one phase of a comprehensive research program, sponsored by the U.S. Atomic Energy Commission, into the relation of radioactive materials to sanitary engineering. Discharge of radioactive wastes by this large new industry and by the users of its products, together with the effluents which will be forthcoming with the projected expansion of industries utilizing nuclear energy, has given rise to a new type of stream pollution with which the water works engineer must be prepared to cope. Added to the normal peacetime activities of the industry is the prospect of atomic and radiological warfare. These problems have become

the subject of much discussion and have evoked many questions from water works engineers and managers. This discussion will cover some of the more pertinent questions and suggest means by which a few of them may be answered through research and correlation of existing information on atomic energy.

The likelihood of an atomic attack resulting in a water contamination hazard is extremely remote when certain aspects of the employment of nuclear fission against urban areas are considered (1). As the possibility does exist, however, its effects should be evaluated, because a safe water supply is essential to public health.

Radiation Sources

There are three sources of residual nuclear radiations resulting from the burst of an atomic bomb—unfissioned uranium (U^{235}) or plutonium (Pu^{239}), neutron-induced radioactivity and the so-called fission products. These products are similar to those from a nuclear reactor and are considered to be the most likely cause of a residual radiation hazard. For these radioactive isotopes to enter a water source in appre-

TABLE 1

Emergency Tolerance Levels for Radioactivity in Drinking Water (2)

Duration of Exposure	Decay	
	Beta-Gamma	Alpha
	<i>microcuries per ml.</i>	
10 days	9×10^{-2}	5×10^{-3}
30 days	3×10^{-2}	1.7×10^{-3}

ciable quantities, however, the atomic explosion must take place in a reservoir or on the adjacent watershed, and the intentional deployment of the bomb in this fashion is very improbable. In any event, radioactive decay, dilution and removal by natural agencies would all contribute to the reduction of the radioactive contaminant in the water supply. Emergency tolerance levels of radioactivity currently recommended are shown in Table 1.

Shipments of radioisotopes from the Operations Division of the Oak Ridge National Laboratory for experimental tracer and therapeutic purposes has experienced a sixfold increase since 1947. Iodide (I^{131}) and phosphorus (P^{32}) have constituted over two-thirds of the shipments, and their entry into sewers and receiving waters has become a problem of increasing concern to state and local health departments. If the provisions of the "Interim Recommendations" (3) are followed closely by isotopes users, it is doubtful that serious sewer contamination will result, although some attention should be given to concentration by slimes. That these isotopes are being released in relatively small quantities is demonstrated by the estimate that an average yearly flow of 10 to 20 cfs. would adequately dilute the total distribution of I^{131} and P^{32} below tolerance levels.

Significant Future Source

Probably the most significant future source of radioactive water contaminants is the atomic energy industry itself. Power-producing reactors are in the advanced stages of development, their future application being a matter of economics. Several types are under construction, including one which is known as a "breeder pile," the function of which is to convert nonfissionable U^{238} and thorium into U^{235} and Pu^{239} , thereby increasing the world's resources of reactor fuel materials tremendously. As these developments are put into practical application, possibly as industrial power sources, an ever-increasing waste problem may be created. The great quantities of process and cooling waters necessary for such operations, especially if the cooling is of the flow-through type, will necessitate the establishment of a careful balance in stream utilization between their disposal and normal domestic and industrial water uses. The ideal goal of the atomic energy industry is to make certain that no radioactive substances are released from its installations. This standard is, of course, virtually impossible to attain and may not even be economically feasible to approach in the future.

Unique Characteristics

Radioactive isotopes which are present in the waste products of fission or are induced by neutron bombardment differ in several basic ways from pollutants present in ordinary domestic and industrial wastes. Many of the individual isotopes are chemically identical with elements encountered daily in food and water. The removal of a particular radioactive isotope would therefore require the removal of much larger quantities of the stable form of

elements which have similar chemical properties and are found in the same group of the periodic table. The permissible concentrations, when expressed in parts per million, further emphasize the unique nature of the removal problem. The recommended permissible level of I^{131} , for example, 3×10^{-5} microcuries (μc) per ml. (4), which is equivalent to 2.4×10^{-10} ppm.

The most attractive measures for the removal of radioisotopes now under study by various AEC organizations and contractors include evaporation, chemical coagulation or carrier precipitation, ion exchange resins and clays, and biological adsorptive or assimilation processes. It is apparent that the wastes of the atomic energy industry present a far-reaching problem, one that will not permit procrastination in providing countermeasures such as prevailed during the development of current stream pollution conditions.

Scope of Present Research

The problem of the removal of radioisotopes from water is essentially one of selective removal of specific elements present in the ionic form when these elements include a sufficient number of radioactive species to constitute a health hazard. It is a problem that must be studied by a consideration of the basic sciences and by pilot plant applications, to substantiate techniques developed from fundamental research.

Radioactive phosphorus (P^{32}), as orthophosphate, was selected for these studies. This choice was made because of the widespread tracer applications and relative ease of handling and counting of this particular radioactive element. Furthermore, P^{32} may be produced in reactor cooling waters that are high in sulfates. Coagulants studied included alum and ferric sulfate.

Kaolinite and montmorillonite clays were employed to simulate natural turbidities and to serve as coagulant aids. After preliminary jar tests of Cambridge, Mass., tap water, three typical surface waters were synthesized for the detailed study. The analyses of these waters are shown in Table 2.

Waters Tested

The waters tested include a soft New England water, a middle western water of good coagulating characteristics and a hard water enabling the use of a softening process.

TABLE 2
Chemical Analyses of Synthetic Water

Material	Boston	Ohio R.	Scioto R.
	ppm.		
Mg ⁺⁺	1.0	7.0	22.4
Ca ⁺⁺	4.4	30.0	68.2
Na ⁺	6.0	26.3	12.2
Cl ⁻	3.5	25.0	18.8
SO ₄ ⁻	9.8	66.0	106.0
HCO ₃ ⁻	16.0	70.0	186.5
TOTAL	40.7	224.3	414.1
Alkalinity	13.0	57.0	152.0
Hardness	15.0	104.0	262.0

tening process. Jar tests of removals of P^{32} by coagulation were made on each water, under a variety of turbidities and coagulant dosages. Pilot plant runs were limited to Cambridge tap water and Ohio River water.

Phosphorus may appear in surface waters as inorganic phosphates, which are for the most part orthophosphates, and as organic phosphates associated with microorganisms. Organic phosphorus removal is not considered here since it entails the removal of particulate matter which is accomplished, to a great extent, by normal coagulation and filtration processes. Unpolluted

surface waters seldom exceed 0.02 ppm. orthophosphate as phosphorus, although lakes receiving biologically treated sewage effluents may reach 0.5 ppm. (5). Studies by the Massachusetts Dept. of Public Health indicate phosphorus concentrations of well and surface waters ranging from 0.001 to 0.10 ppm.

Coagulation jar tests were made to determine the effect of phosphate concentration on the percentage removal of radioactive and carrier phosphorus.

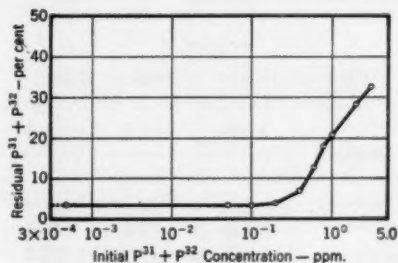


Fig. 1. Effect of Phosphate Concentration on Removal of Radioactive and Carrier Phosphorus

Alum was applied in the jar tests at a concentration of 10 ppm. and bentonite at 6 ppm. The concentration of tracer P^{32} was constant and was equivalent to 5.4×10^{-3} ppm. P^{31} .

This effect is illustrated for Boston water at a single coagulant dose by Fig. 1. Below 0.2 ppm. P^{31} little change in the percentage removal was detectable. Above 0.4 ppm. P^{31} the phosphate increasingly inhibited floc formation. For these reasons, an orthophosphate concentration of 0.10 ppm. (as P^{31}) was selected as representative of the upper limit of inorganic phosphates that might be expected in surface waters. In all tests only sufficient radioactive phosphorus

(P^{32}) was added to make radiological tracer assays on the raw and treated samples convenient. It is interesting to note that if the 0.1 ppm. phosphorus present were all radioactive, it would be equivalent to 27 curies of P^{32} per l. It is important to keep in mind that the level of radioactivity of the water in no way influenced the percentage removal factor, since the radioactive phosphorus added is chemically insignificant when compared to the 0.10 ppm. of stable phosphorus concentration employed.

Procedures

Coagulation procedures employed in water treatment are designed to remove negatively charged particulate matter. This is brought about by the partial neutralization of charged turbidity particles by their adsorption of multivalent coagulant ions, the mutual coagulation of the partially discharged negative particles with positively charged hydrous oxide particles and by the growth of the resulting neutral floc-turbidity units, with the aid of the hydrous oxide binder, into particles of sufficient mass and density to settle under the influence of gravity. In the form of the orthophosphate radical (PO_4), the isotopes P^{31} and P^{32} are removed from the liquid phase during the formation of a hydrous oxide floc either by adsorption on the surface of the floc particles or by incorporation isomorphously within the crystalline lattice of the micelle. Studies of this phenomenon have indicated adsorption to be the predominating mechanism in phosphate removals with ferric sulfate. That phosphates are preferentially adsorbed over many other anions may be explained by the low solubility of phosphates and by the Schulze-Hardy Law

which states that the higher the valence of the precipitating ion relative to the ion to be precipitated, the greater the precipitating power of the electrolyte (cation). These conditions are met to an optimum degree with Al^{+++} or Fe^{+++} ions and PO_4^{--} .

Preliminary studies were also made of the removal of radioactive iodine (I^{131}), obtained as NaI and present as

the simultaneous testing of six 1-l. samples under constant temperature control to $\pm 1^\circ F$. This equipment was used for fundamental research on the mechanism of coagulation as applied to the removal of ions.

Synthetic waters were prepared with distilled water in 19-l. carboys to which both 0.1 ppm. P^{31} and a tracer quantity of P^{32} were added. Radioactivity

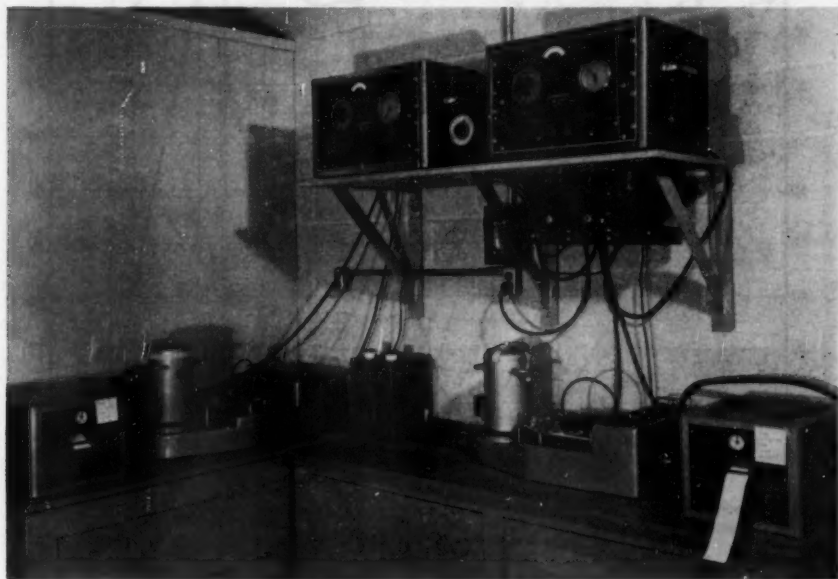


Fig. 2. Radiological Assay Equipment

the iodide ion, and strontium (Sr^{90}), present as the Sr^{++} ion at those conditions providing an optimum reduction of P^{32} . A comparison of these data demonstrates markedly the varying chemical nature of substances so often collectively referred to as *radioactivity*.

Jar Tests

Coagulation jar tests were carried out on mixing equipment permitting

assays were made to establish the number of counts per second (cps.) per ml. in the untreated water. This number normally ranged from 50 to 200 cps. per ml. One-liter samples of the various waters were dosed with the desired clays and coagulants and stirred at $60^\circ F$. for 30 minutes. After the samples had settled for one hour, analyses were made for residual radioactive phosphorus. The proportion of initial

concentration $P^{31} + P^{32}$ was calculated as the ratio of counts per second per liter of the treated to the untreated water.

Equipment

Two complete Tracerlab* counting units were employed, each consisting

ice copper planchets. Samples were then counted and the results expressed in counts per second.

Removals of P^{31} and P^{32} from the various waters by coagulation and sedimentation are shown in Fig. 3 and 4. These curves show that waters of low alkalinity and total solids content, rep-

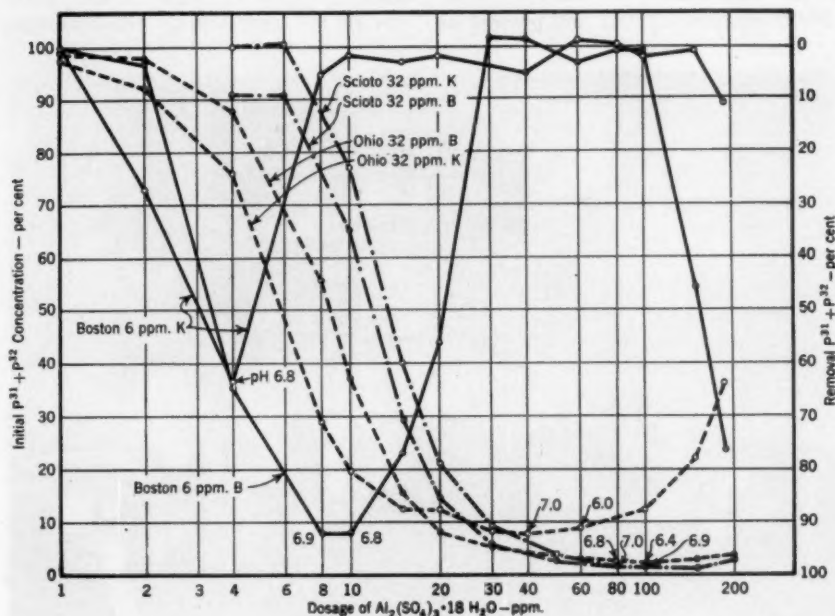


Fig. 3. Phosphate Removal by Alum Coagulation

The initial P^{31} concentration was 0.10 ppm.

Key

B—Bentonite turbidity
K—Kaolinite turbidity

of an SC-1 Autoscaler,* an Automatic Sample Changer,* a Geiger-Mueller tube and a Tracergraph* (Fig. 2). Samples were prepared in triplicate by evaporating 1-ml. portions of liquid from each beaker on three single serv-

*A product of Tracerlab, Inc., Boston, Mass.

resented by the Boston water, exhibit an optimum range of coagulant dosages. As alkalinity and total solids increase (Ohio and Scioto River waters) the zone of optimum removal of phosphates shifts to the right and maximum removals become greater. Optimum removals always corresponded to the

shortest times of floc formation. The increase in residual P^{31} and P^{32} concentration with increasing coagulant dose, observed in Boston water, is caused by peptization of the hydrous oxide floc brought about by the increasing Al^{+++} and H^+ ion concentrations. The greater sulfate content and buffering capacity

tween 0, 6 and 32 ppm. kaolinite turbidity (curves for 0 and 32 ppm. kaolinite are not shown). The addition of turbidity in the form of bentonite, however, increased and broadened the range of optimum removals and shifted this range to higher coagulant dosages. Langelier (6) explains the shift in

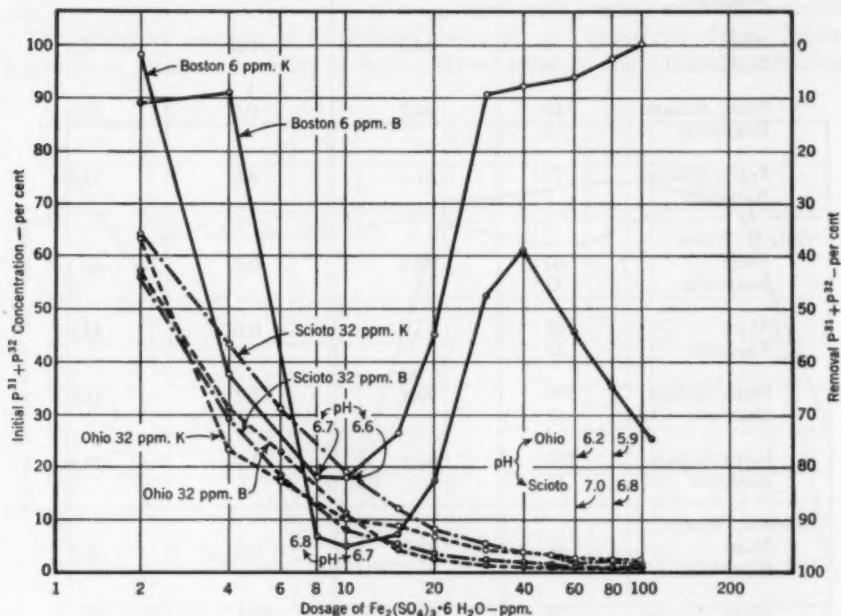


Fig. 4. Phosphate Removal by Ferric Sulfate Coagulation

The initial P^{31} concentration was 0.10 ppm.

Key

B—Bentonite turbidity
K—Kaolinite turbidity

of the Ohio and Scioto River waters effectively broadened this range.

Effect of Turbidity

The effect of turbidity on the removal of phosphate by coagulation was most noticeable in Boston water. In this water, there was little difference be-

terms of the higher exchange capacity and consequent greater coagulant demand of the bentonite. Increased removals can be explained by the greater surface area available for phosphate adsorption. The optimum range is broadened because a greater concentration of A^{+++} and H^+ is necessary before

TABLE 3

Comparison of P^{32} , I^{131} and Sr^{90} Removals at Optimum Conditions for the Removal of P^{32}

Conditions			Removal—per cent		
			$P^{32}(PO_4^{+++})$	$I^{131}(I^-)$	$Sr^{90}(Sr^{++})$
Boston Water	ppm.				
Alum	40		98.8	0.0	9.4
Bentonite	32				
Alum	4		63.3	0.0	4.8
Kaolinite	6				
Ferric Sulfate	10		94.9	0.0	36.0
Bentonite	6				
Ferric Sulfate	10		81.7	0.0	25.5
Kaolinite	6				
Ohio R. Water					
Alum	60		98.0	0.0	46.3
Bentonite	32				
Alum	40		92.0	0.0	42.6
Kaolinite	32				
Ferric Sulfate	100		99.4	6.3	44.0
Bentonite	32				
Ferric Sulfate	100		98.3	7.7	20.8
Kaolinite	32				
Scioto R. Water					
Alum	50		97.4	5.0	56.5
Bentonite	32				
Alum	50		96.8	12.2	53.7
Kaolinite	32				
Ferric Sulfate	100		98.6	4.6	58.0
Bentonite	32				
Ferric Sulfate	100		98.6	9.0	54.7
Kaolinite	32				
Ca(OH) ₂	150		98.9	5.5	73.9
Na ₂ CO ₃	60				

peptization takes place. As the exchange capacity, and thus the total negative charge of the clay particles, increases, the removal of phosphate also increases.

It is possible, however, that because of the low alkalinity and total solids of Boston water, no hydrous oxide micelle is formed. If so, the high removals of phosphate become more dif-

difficult to explain. Experiments by the authors have shown that phosphate cannot be removed by kaolinite and bentonite coagulation alone. It might be postulated, therefore, that the Al^{+++} or Fe^{+++} , which coagulates the clay particle, becomes hydrolyzed and subsequently attracts the phosphate ion and carries it down with the coagulated clay.

The effects of turbidity on Ohio and Scioto River waters are similar to those

is believed that residual turbidity would be a good measure of plant efficiency in the removal of phosphates. It should also be noted that at higher alum dosages, although nearly complete turbidity removal is achieved, the residual phosphate increases progressively.

Additional Studies

Additional studies were made on the removal of phosphate from Scioto River water by the lime-soda softening

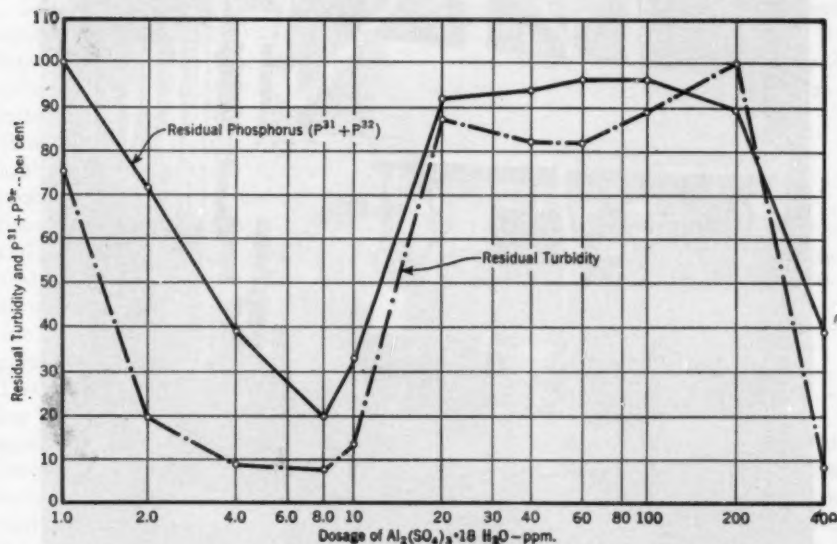


Fig. 5. Comparison of Kaolinite Turbidity and Phosphate Removals From Boston Water With Alum

The initial P^{31} concentration was 0.10 ppm.

described for Boston water. Because of the increased alkalinity and total solids content of these waters, however, the peptization at higher alum dosages does not occur.

A correlation between phosphate and turbidity removal is shown in Fig. 5. Since the optimum removal portions of the curves follow each other closely, it

process. At optimum softening doses of lime and soda ash approximately 99 per cent of phosphate was removed. Varying lime doses, above and below the optimum for softening, increased the residual phosphate and residual hardness proportionately. Varying the soda ash dosage produced the expected effect on residual hardness but had no



Fig. 6. Rapid Sand Filtration Pilot Plant

effect on phosphate removal. These tests show that phosphate can be removed from a hard water by the lime-soda softening process.

A comparison of P^{32} , I^{131} and Sr^{89} removals under conditions which were

optimum for the removal of P^{32} (Table 3) indicates that conditions which give excellent removals of phosphate give only fair removals of strontium and no removal of iodine. This result emphasizes the fact that the removal of radio-

activity from a water depends upon the chemical or ionic form in which that radioactivity appears.

Maximum removals of I^{131} were approximately 15 per cent. The addition of small amounts of carrier I^{127} had no effect on removals. These low removals of iodine are probably due to both the single negative charge on the iodide radical and the relatively high solubility of the iodides.

Strontium Removal

Strontium removals by chemical coagulation varied from 10 to 55 per cent, depending upon the type of water, the turbidity and the coagulant. These results correspond to those reported by Straub (7) for removals by alum coagulation. Strontium removals are probably accomplished through the exchange of positive ions on the kaolinite and bentonite clays, a reaction previously described by Langelier (6). In all waters it will be seen that bentonite, due to its greater exchange capacity, gives higher removals than kaolinite. Two experiments were performed using bentonite alone with 5 minutes' coagulation and 17 hours' settling. Strontium removals were 36.3 per cent with 100 ppm. bentonite and 44.0 per cent with 400 ppm. bentonite. Lauderdale (8) reports that higher doses of bentonite, without the addition of a coagulating electrolyte, will produce removals as high as 80 per cent. Maximum removals of strontium (84 per cent) were obtained by the lime-soda softening process. This reaction is to be expected, since the lime-soda process is designed to remove Ca^{++} and Mg^{++} , which are in the same group as Sr^{++} in the periodic table.

Lauderdale (8) reported removals of mixed fission products from water by using a phosphate coagulant. The

phosphate floc was formed by adding the radioisotope and either KH_2PO_4 or Na_3PO_4 to a solution of $Ca(OH)_2$ in distilled water. Results varied from a proportional removal of 10.7 per cent for W^{188} to 99.9 per cent for Ce^{144} and Y^{91} . Maximum removals of Sr^{89} using Na_3PO_4 amounted to 97.8 per cent.

Pilot Plant Studies

The pilot plant (Fig. 6) included six rapid sand filters, each 2 in. in diameter, with a 24-in. sand depth. The effective size and uniformity coefficient of the sand is shown in Table 4.

Special filter rate controllers insured control of flows at the standard filtra-

TABLE 4
*Effective Size and Uniformity Coefficient
of Sand in Pilot Plant*

Filter No.	Effective Size mm.	Uniformity Coefficient
1 and 2	0.62	1.34
3 and 4	0.51	1.41
5 and 6	0.41	1.51

tion rate of 2 gpm. per sq.ft. A two-compartment coagulation tank having a 45-minute detention period and equipped with vertical mixing paddles was followed by 3.5 hours' detention in a rectangular sedimentation tank.

Cambridge city water was first demineralized to provide a mineral-free water from which various synthetic waters could be compounded. Heating to approximately 95°F. and subsequently cooling provided a partially de-aerated water at 60°F. for the tests. A three-chamber mixing basin permitted the consecutive addition of chemicals, turbidity, carrier and radioactive isotopes, and coagulants to the water. All chemicals were added at a

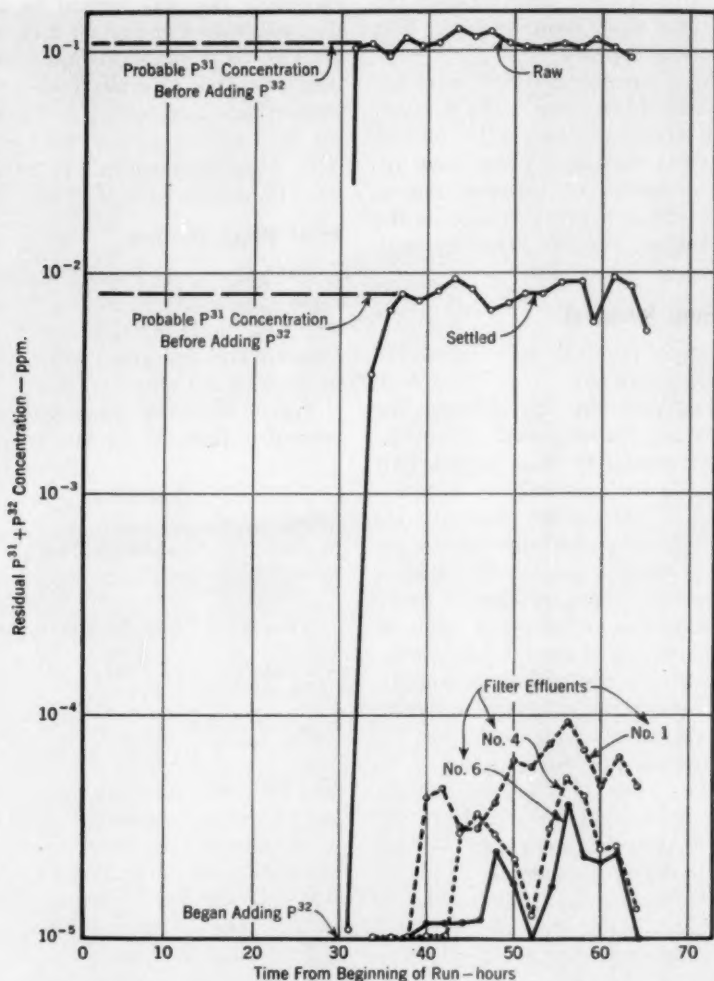


Fig. 7. Phosphate Removal by Coagulation With Ferric Sulfate From Ohio River Water
 During pilot plant run No. 4, the pH value was 7.8-8.3; alkalinity was 65-85 ppm.;
 turbidity 32 ppm.; orthophosphate 0.10 ppm.; and $\text{Fe}(\text{SO}_4)_6\text{H}_2\text{O}$ 60 ppm.

Run No.	Filter Sand Characteristics		No. of Washes
	Effective Size mm.	Uniformity Coefficient	
1	0.62	1.34	0
4	0.51	1.41	1
6	0.41	1.51	3

constant rate by a positive displacement pump.

Five runs have been made on the pilot plant (Table 5). Hourly observations of rates of flow, filter head losses and temperature of raw and filtered water were made. Samples of raw, settled and filtered water were taken at 30-minute intervals, com-

more than twenty times greater than that in run No. 1. In terms of tolerance concentrations, therefore, these small differences in percentage removals can become very significant. Table 5 also emphasizes the importance of good coagulation and sedimentation prior to filtration, since these processes were not as efficient in runs No. 1 and

TABLE 5
*Removal of P^{31} and P^{32} by a Rapid Sand Filtration Pilot Plant**

Run No.	Water	Coagulant (ppm.)	Proportional Removal $P^{31} + P^{32}$ Over Duration of Run			Decontamination Factor = $\frac{P^{31} \text{ initial}}{P^{31} \text{ final}}$
			Coagulation and Sedimentation	Filtration Avg. of Six Filters	Total for Plant	
			<i>per cent</i>			
1	Cambridge	alum (100)	74.5	98.30	99.57	232
2	Cambridge	alum (100)	81.0	99.62	99.93	1430
3	Cambridge	ferric sulfate 30-40	80.9	99.40	99.89	910
4	Ohio R. (turbidity, 32 ppm.)	ferric sulfate (60)	93.7	99.63	99.98	5000
5	Ohio R. (turbidity, 32 ppm.)	alum (48-60)	67.0	98.83	99.61	256

* Initial P^{31} Concentration is 0.10 ppm.

posited over a 2-hour period and measured for pH, alkalinity and radioactivity.

Phosphate Removal Comparison

A comparison of phosphate removals by the various plant elements and the over-all plant for all five runs is given in Table 5. It is significant that, although the proportion removed for the total plant exceeded 99 per cent for all runs, the decontamination factor varied considerably. For example, the decontamination factor in run No. 4 was

5, and lower decontamination factors were observed.

More detailed results of runs No. 4 and 5 are shown in Fig. 7 and 8. Run No. 4 differs from the other runs in that P^{32} was added only during the latter half of the run, in order to trace the removal of P^{31} which was added throughout the entire run. Alkalinity and pH of the settled water are shown below.

Run	pH	Alkalinity—ppm.
4	6.4-6.8	30-45
5	6.7-7.2	35-45

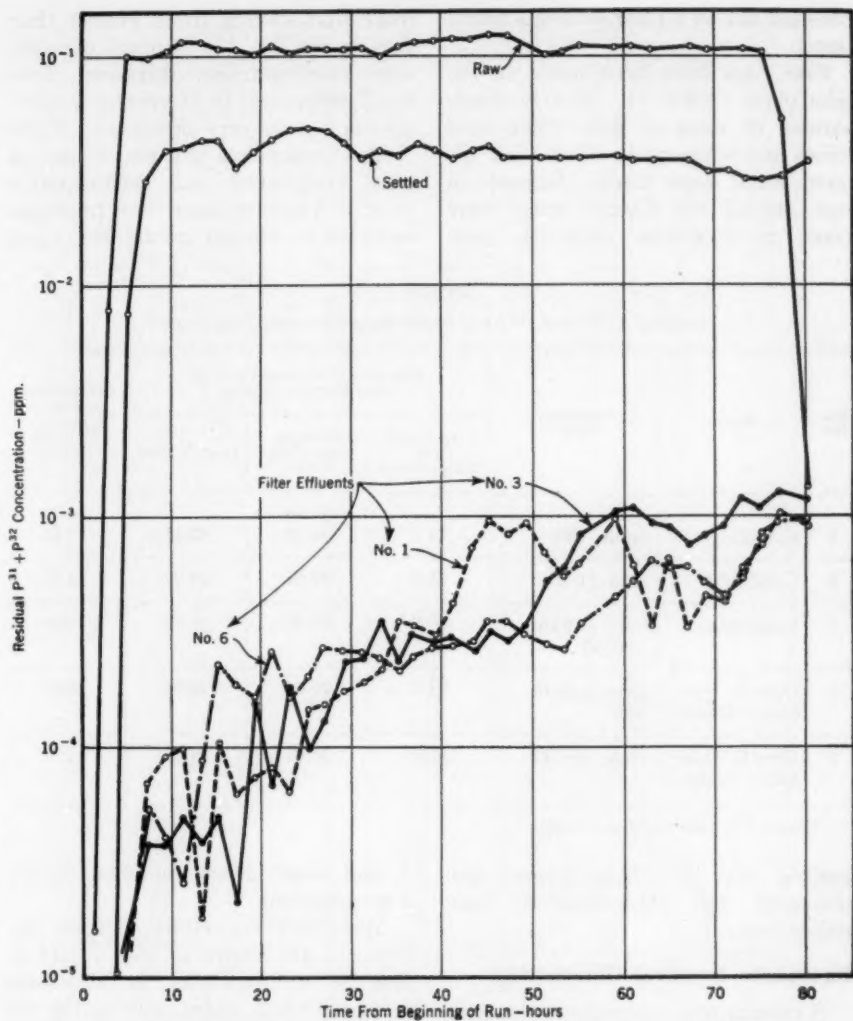


Fig. 8. Phosphate Removal by Alum Coagulation From Ohio River Water

In pilot plant run No. 5, the pH value was 7.9-8.2; the alkalinity was 58-70 ppm.; turbidity 32 ppm.; orthophosphate 0.10 ppm. as P^{31} ; and $Al_2(SO_4)_3 \cdot 18H_2O$ was 45-60 ppm.

Filter Sand Characteristics

Run No.	Effective Size	Uniformity Coefficient	No. of Washes
1	0.62	1.34	1
3	0.51	1.41	1
6	0.41	1.51	4

Figure 7 shows that, with effective coagulation and sedimentation, the efficiency of phosphate removal increased with decreasing sand size. This increase was, however, quite small and was masked in run No. 5 by the greater load placed on the filters because of poor coagulation and settling. Phosphate concentrations in the filter effluent increased as each run progressed but seemed to reach a maximum after 50-60 hours.

Following runs No. 3 and 4, an analysis of the sand was made to determine the depth at which the phosphate was retained. It was found that phosphate retention generally decreased with depth. It was also observed that penetration decreased as the effective size of the sand decreased. The behavior of phosphate in this respect is similar to the behavior of floc in a rapid sand filter.

Other Phosphate Studies

Studies were also made to determine the removals of phosphate by rapid sand filters through sand adsorption alone. Uncoagulated Ohio River water with P^{31} and tracer amounts of P^{32} was passed through three filters containing the same sand sizes as those employed in the pilot plant. It was found that only 9.8 per cent of the phosphate applied was removed by sand over a 72-hour period. At the end of this period the rate of removal was negligible.

The relationship between phosphate and floc retention in a rapid sand filter, and the small amounts of phosphate removed by sand adsorption alone indicate that the coagulation process is the major mechanism for the removal of phosphate from water. The function of the rapid sand filter is simply to

remove floc particles which have previously adsorbed phosphorus but are too small to settle in the sedimentation tank. It then follows that backwashing, if carried out satisfactorily, removes nearly all of the radioactive phosphorus retained by the filters.

Conclusions

On the basis of the research conducted, several conclusions have been drawn:

1. Optimum removals of P^{31} and P^{32} result at conditions of good coagulation, as evidenced by the rapid formation of large, easily settleable flocs and optimum turbidity removals.

2. High-exchange capacity clays improve phosphorus removals, particularly in waters that are low in alkalinity and total solids content. Such clays also increase the coagulant demand and broaden the range of coagulant dosages over which high efficiencies are possible.

3. Clays, including bentonite, will not bring about appreciable removals of P^{32} unless used in conjunction with hydrolyzing coagulants.

4. Multivalent cations such as Sr^{80} are best removed by coagulation processes that produce negatively charged floc. High-exchange capacity clays, lime-soda softening or phosphate-lime coagulation may accomplish this end depending on the degree of removal required.

5. Filtration efficiencies in removing radioactive phosphorus are closely allied to the degree of clarification achieved by coagulation and sedimentation. Orthophosphate is removed during filtration by the removal of the floc fraction passing the settling basin, rather than by direct adsorption on the sand particles.

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Discussion

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The authors' paper on the removal of radioisotopes by water purification methods deserves careful study by all interested in decontamination of radioactive waters. The research carried out using three representative types of surface water supplies in America as well as three isotopes of widely different characteristics is a valuable contribution to the water supply field.

This research project was sponsored by the Atomic Energy Commission as a service to the public works and public health professions under its general policy of evaluating the environmental effects of atomic energy products and by-products on community life and property in "learning to live with radiation." At the Oak Ridge National Laboratory and in cooperation with the U.S. Public Health Service and the Department of Defense, AEC is also sponsoring similar, well controlled research using mixed fission products as contaminants.

It is well to emphasize that the research reported on by the authors deals

primarily with radioactive phosphorus as a contaminant. Enough work was done, however, with radioactive iodine and strontium to show striking differences in their behavior. Results in decontamination by the overall rapid sand filtration method are highly encouraging for phosphorus, a well known metabolite in nature, although they are quite discouraging for iodine. With strontium as a contaminant, the lime and soda ash treatment of hard waters is superior to any of the other treatments.

Only Solutions for Tests

It should be remembered that these experiments were made on radioactive solutions and not particulate matter. One would expect that particulate matter would generally be more easily removed by coagulation and settling. Data are unfortunately quite meager as to particle size and behavior of sub-micron-size radioactive materials in water. Much more research will be needed in this field before principles of the effectiveness of orthodox water purification methods in removing all radioactive contaminants from water are established with the same degree of surety that is customary in the profes-

sion in dealing with other contaminants of water.

The Massachusetts Inst. of Technology findings on decontamination of water are, in many ways, in line with expectations based on experience with removing turbidity, bacteria and other contaminants from water. The most significant fact revealed by these investigations is that efficient pretreatment is the most effective means of removing radioactivity. The alert water purification plant operator is aware of this fact, but pretreatment is not always under good technical control. It is to be hoped, therefore, that this report will stimulate more water works officials to give greater attention to control of pretreatment methods and facilities. Should a source of water supply become contaminated by radioactive materials, the most helpful precautionary measure which might be taken at an existing rapid sand filter plant would certainly be to coagulate and settle the water under the best possible conditions. Since materials removed by this process may contain long-lived radioactive isotopes, care must be taken in disposing of basin sludge, to prevent other downstream sources of water supply from becoming contaminated. Holding such wastes in temporary lagoons until decay of activity to a safe level takes place would be a reasonable precaution.

Differences in Sand Sizes

The authors report very little difference in filtration efficiency in the experimental filters among the various sand sizes within the customary range. It is probable that with other radioisotopes, differences may exist. The characteristics of the sand and the condition of the sand surface may also significantly affect the ability to remove

radioactivity. The apparent tendency of certain radioactive materials to become attached to sand grains in a filter is not well understood but is under study.

It is most important that the efficiency of slow sand filters in removing radioactivity in water be determined, so research in this field is contemplated in the continuing water decontamination program at Massachusetts Inst. of Technology.

Contamination Sources

Since emphasis has been given to the need of studying each of the radioactive isotopes that might possibly contaminate a water supply, potential sources of these contaminants should be discussed, so that water works officials will have more adequate background material to be used when evaluating their problems. Radioactive waste can be released from four principal sources: [1] at the places where isotopes are used, [2] at the plants processing radioactive products, [3] in transporting radioactive materials and by the discharge of an atomic weapon.

The users of isotopes are currently under close supervision by the AEC, and the quantities in use are relatively low in amount and activity. Radioactive phosphorus and iodine represent about 67 per cent of the isotopes now being shipped. The waste products reaching public sewer systems are small, and the likelihood that waste from these sources will contaminate public water supplies, under present conditions of use and control, is remote.

At production and research plants in the atomic energy industry, large quantities of radioactive waste products are produced, stored and processed. Only through a serious acci-

dent could these wastes contaminate a public water supply source significantly. The type, character and properties of wastes at a given production area are known, and advance plans to treat any potential contamination of a downstream water supply may be developed by responsible public health and water works officials with the cooperation of the plant manager.

The likelihood of a spill while transporting radioactive materials is remote

are released by a bomb burst, as well as fragments of the fissionable material that makes up the bomb. In the form of particulate material and aerosols, these explosion products could contaminate a local area or, depending on the nature and altitude of the burst, be carried aloft by the bomb cloud. Upon falling they could contaminate watersheds, sources and open reservoirs. Some of the more important fission products of U^{235} , based on pro-

TABLE 1
Selected High-Yield Fission Products of U^{235} *

Fission Product	Mass No.	Yield	Half Life	Decay
		<i>per cent</i>		
Barium	99	6.2	67.0 hours	Beta ⁻ , gamma
Cerium	95	6.4	65 days	Beta ⁻ , gamma
Cerium	95	—	35 days	Beta ⁻ , gamma
Cesium	94	5.0	20 minutes	Beta ⁻ , gamma
Columbium	91	5.9	57 days	Beta ⁻
Molybdenum	92	5.1	2.7 hours	Beta ⁻
Strontium	91	5.0	9.7 hours	Beta ⁻ , gamma
Strontium	90	—	25 years	Beta ⁻
Strontium	89	4.6	53 days	Beta ⁻
Strontium	137	—	33 years	Beta ⁻ , gamma
Yttrium	140	6.1	12.8 days	Beta ⁻ , gamma, electron
Yttrium	141	5.7	28 days	Beta ⁻ , gamma
Zirconium	144	5.3	275 days	Beta ⁻

* See reference 1.

because of special precautions taken in packing them. Shipments of sizable quantities are accompanied by trained radiologists who are equipped with detection instruments and trained in decontamination techniques. Should a source of water supply become contaminated they could identify the contaminant and determine levels of activity released, and thereby prescribe proper treatment.

The unknown factor is the potential contamination resulting from use of radioactivity as a weapon. It is known that highly radioactive fission products

portional yield and half life (1), are listed in Table 1.

Need for Investigation

The effectiveness of water purification plants and processes in removing contamination by each of these fission products should be investigated. This contamination may be local, or it may be carried hundreds of miles, depending on meteorologic conditions. After a bomb blast the assistance of a meteorologist as well as a radiologist is of great importance to a water works operator.

In addition to fission products and unfissioned bomb material, the neutrons released by the blast irradiate many materials present in the vicinity, making them radioactive also. Should the blast be in the vicinity of a water works intake or plant, these irradiated substances could become water contaminants. If the level of activity is high and the half life of the isotope long, this reaction will be of great significance.

A list of some of the more common radioactive isotopes of elements with which water works operators are familiar is given in Table 2.

TABLE 2
Common Radioactive Isotopes

Radioisotopes	Atomic Mass	Half Life	Decay
Sodium	24	14.8 hours	Beta, gamma
Sulfur	35	87.0 days	Beta
Calcium	45	180.0 days	Beta, gamma
Iron	59	44.0 days	Beta, gamma
Copper	64	12.8 hours	Beta
Barium	140	12.8 days	Beta ⁻ , gamma
Iodine	131	8.0 days	Beta ⁻ , gamma
Phosphorus	32	14.3 days	Beta

Summary

Both the Massachusetts Inst. of Technology and the Oak Ridge National Laboratory researches into water decontamination should be extended on a wide range of specific isotopes as contaminants. Waters of representative chemical compositions must be treated by multiple purification methods before an adequate range of answers is available upon which to evaluate fully the efficiency of current water purification methods. At both Oak Ridge and Massachusetts Inst. of Technology, the importance of common

coagulating chemicals, good mixing and settling has been demonstrated for phosphorus and strontium. Both laboratories demonstrated the difficulty of removing radioactive iodine by orthodox treatment. At Oak Ridge, it has been shown, on a laboratory scale, that mixed fission products can be removed from contaminated water by passing it through a selected series of ion exchange materials.

The AEC plans to continue to cooperate with the national laboratories, universities and other federal agencies in carrying out research on water decontamination until adequate methods are developed which will help the nation's water works operators meet the problem of radioactive contamination if their sources of supply become seriously affected.

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The authors have brought out some very good points and some pertinent information which those who are interested in the removal of radioactivity from water should consider.

As most water works operators are interested in radioactivity from the standpoint of contamination of water supplies, they must realize that the chemical elements with which this activity is associated will be unknown to them. Although P³² was the element most extensively investigated in these studies, some work was done with I¹³¹ and Sr⁸⁹. The data show that the re-

removal of radioactivity from a water depends upon the chemical or ionic form in which that radioactivity appears. Conditions which gave excellent removals of phosphate gave only fair removals of strontium and no removal of iodine.

Atomic Bomb Radioactivity

If contamination is caused by an atomic bomb, the radioactivity will be

so well, if at all, by the usual chemical treatments.

This writer does not agree with the fourth conclusion that high exchange capacity clays, lime-soda softening or phosphate-lime coagulation will remove Sr^{90} , nor do the data prove it. When one is discussing the removal of radioactivity, removals of 99 per cent or greater are essential. It is true that high exchange capacity clays help in

TABLE 1

Removal of Added Mixed Fission Product Radioactivity from Drain Waste by Chemical Treatment

Chemical Added				pH	Radioactivity Added, Beta			Beta D.F. §	Removal per cent	Remarks
Lime	FeCl ₃	Silica Product	NaOH		cpm./ml.*	d/m/ml.†	μc/ml.‡			
91	—	ppm. —	—	9.6	83	690	3.1×10^{-4}	8.9	89	Coagulation tests:
120	—	—	—	10.9	3,200	2.7×10^4	1.2×10^{-2}	4.6	78	5 min. mixing
—	51	—	51	8.1	107	890	4.0×10^{-4}	11.0	91	15 min. flocculation
—	—	86	51	9.1	107	890	4.0×10^{-4}	12.0	92	2 hr. settling
120	—	68	—	10.7	3,200	2.7×10^4	1.2×10^{-2}	5.1	80	
154	77	—	—	8.2	97	810	3.7×10^{-4}	12.0	92	
154	68	—	—	11.1	3,200	2.7×10^4	1.2×10^{-2}	4.9	80	
68	51	—	—	9.2	59	490	2.2×10^{-4}	12.0	92	

* Counts per minute per ml. (end-window Geiger-Mueller tube counter, 12 per cent yield).

† Disintegrations per minute per ml.

‡ Microcuries per ml.

§ Decontamination factor = $\frac{\text{radioactivity added before treatment}}{\text{radioactivity remaining after treatment}}$

that of mixed fission products. This means that any or all of the radioactive elements between No. 30 (Zn) and No. 64 (Gd) in the periodic table may be present. The elements which are physiologically most hazardous are those which the survey has covered, I^{131} and Sr^{90} . These, as has been pointed out, are not removed nearly

the removal of strontium, but the proportional removals are low, 42–58 per cent. Lime-soda softening increased removal to only 74 per cent. It would have been interesting if the researchers had passed the effluent from coagulation experiments with I^{131} and Sr^{90} through a rapid sand filter as was done with P^{32} . There is certainly no doubt,

from the data presented, that a water treatment plant which employs sand filtration in addition to coagulation will remove the radioactivity if it is all in the form of P^{32} .

Work at Argonne Laboratories

Some work has been done in the Argonne National Laboratory to determine how much activity can be removed by the usual water treatment chemicals and dosages, when this activity, in the form of mixed fission products, was added to laboratory drain wastes not containing any sanitary sewage. These sanitary and laboratory drains are separated—the sanitary sewage drains lead to a normal sewage treatment plant, and the laboratory drain waste goes to retention tanks which are monitored for radioactivity before being discharged. If the wastes contain radioactivity, they

are processed for its removal. Some of the results of this study are shown in Table 1.

It will be noted that a decontamination factor (D.F.) of 12 gives a proportional removal of 92 per cent, yet a D.F. of 12 is considered rather insignificant as it would be if the initial counts were approximately 3,200 counts per minute per ml. (cpm. per ml.) or greater. The energy of the activity must also be taken into account. When dealing with a low energy beta particle, such as C^{14} or Ca^{45} , the activity may not be detected if an end-window counter is used, unless one is aware that such activities are present. Special techniques must be employed or a windowless (proportional) counter must be used.

It is hoped that the present studies will be expanded to include other types of radioactivity, particularly mixed fission products.

Authors' Closure

The discussions have raised additional questions which should be clarified to supplement the material presented in the original paper. It has been suggested that comment be included on certain aspects of the recent paper by R. A. Lauderdale and A. H. Emmons (1), since that article is closely related to this one.

With respect to Miss Swope's comment on the inability of high exchange capacity clays, lime-soda softening or phosphate-lime coagulation to remove sufficient Sr^{90} , it must be emphasized that the data presented in the original paper showed removals up to 74 per cent under the particular conditions of the test. These were reported not as representing the maximum obtainable

removals, but merely for comparison with P^{32} removals under conditions which were at an optimum for the removal of the negative phosphate ions.

As a matter of fact, Sr^{90} removals in excess of 97 per cent have been attained in the Sedgwick Laboratories with calcium phosphate floc at conditions of high pH and excess phosphate. This value admittedly does not exceed the 99 per cent removal figure suggested by Miss Swope as minimal. The philosophy of what constitutes removal of radioactivity and what does not, however, is not of primary consideration in this report. In treating radioactive wastes at AEC installations, high separation efficiencies are imperative to meet the rigid standards

governing the deposition of such materials in natural bodies of water. In the removal of radioisotopes during the treatment of water in which radioactivity levels will be much lower, such high efficiencies may not be required, particularly to meet current emergency standards.

Miss Swope has reported on the treatment of mixed fission products taken from laboratory retention tanks. It is very doubtful whether coagulation tests, employing radioisotopes from such a source, may be expected to provide data on the removal of the fission products resulting from an atomic explosion.

Atomic Explosion Products

The radioactive isotopes in the fission products of the atomic explosion are primarily oxides—for the most part insoluble—and probably in the form of radiocolloids. Fission products employed in laboratory coagulation experiments are obtained from the nuclear reactor pile and are predominantly ionic. Tests performed with such material must obviously be interpreted with discretion when applied to the aftereffects of the discharge of an atomic bomb. It cannot be emphasized too strongly that the degree of removal of fission product activity is dependent upon the predominating isotope and upon the chemical forms of the radioisotopes present in the waste. A waste that is high in soluble, monovalent ions would result in little removal. If a high proportion of the radioactivity were due to multivalent ions, however, the degree of removal might be good. The competitive effects of the much higher concentrations of stable ions present in the waste water may also be an important consideration. The nature of the activity

present in the retention tanks is therefore a function both of the age of the waste and of its history prior to treatment.

Unexplored Removal Methods

The article by Lauderdale and Emmons has pointed to new and as yet unexplored methods of removing microquantities of radioactive substances from drinking water. The investigations reported here raise several questions, fundamental to this new phase of water treatment, that perhaps warrant further discussion.

The radioactivity present in no way acts to saturate the resins as might be first concluded from Fig. 2. The quantity of radioactive water which may be decontaminated by an anion-cation resin bed is determined, to a large extent, by the normal mineral content of the water and the exchange capacity of the resin employed. The efficiency of removal of radioisotopes during the effective portion of the demineralization cycle is, of course, also dependent on the exchange ability of the various contaminating isotopes.

The comparative efficiency of steel wool to the other materials tested, as demonstrated by the authors in Table 2 above, is not quite as apparent as it would first seem. The high proportion of radioactivity retained in the steel wool was due primarily to the fact that it was the first material through which the activity passed. Since the quantities of radioisotopes present are chemically insignificant, it may be assumed that the radioactivity does not saturate the various units of the decontaminating process. The removal of a given isotope by a particular unit may be estimated, on a percentage basis, as the ratio of the activity retained to the total activity entering the element. The

percentage factors are applicable, regardless of the activity levels encountered. If a radiochemical assay of the effluent were available, it would be possible to calculate quite closely the true efficiencies of each material. Since little activity remained in the final ef-

TABLE 1
*Estimated Efficiencies of Removals of
Radioisotopes by Various Units*

	Steel Wool	Burnt Clay	Acti- vated Charcoal	Resins*
	<i>per cent</i>			
Ruthenium	95.96	89.6	33	—
Zirconium	99.39	69.7	33	—
Strontium	69.72	58.9	28	—
Total Rare Earths	86.81	99.0	60	—
Cerium	97.13	99.2	12	—
Cesium	59.74	99.3	0	—
Niobium	98.70	44.7	17	—
Tellurium	98.34	54.0	25	—

* Since effluent activities for the various isotopes were not determined, it was not possible to estimate the efficiency of the last unit in the process, the mixed resin bed.

fluent, a reasonable estimate of the individual efficiencies of the various materials for each element is possible. These are shown in Table 1 above. A proper perspective of the efficiency of steel wool and other materials is thus demonstrated.

Determining Efficiency of Materials

The efficiency of each material employed in the decontaminating unit could be determined more accurately by studying it individually and, if possible, with pure, separated isotopes. The proportional removal of a particular isotope such as Sr^{90} by each material would be the same under such conditions as those obtained by the authors. The actual measurements would also be greatly facilitated. The exact identity of the isotopes passing the unit would therefore be determinable and the complicated radioassay unnecessary.

Many water works engineers have asked why the problem of the removal of radioactive isotopes from water cannot be solved immediately. The many facets of this problem, as presented in these papers and discussions should make it apparent that an early solution is impossible. Considerably more research must be undertaken to include the various physical and chemical characteristics of radioisotopes, and to develop new methods for their removal.

Reference

1. LAUDERDALE, R. A. & EMMONS, A. H. A Method for Decontaminating Small Volumes of Radioactive Water. Jour. A.W.W.A., 43: 327 (May 1951).

Deep Well Pump Maintenance

By Harry W. Thomas

A paper presented on Oct. 26, 1950, at the Michigan Section Meeting, Detroit, Mich., by Harry W. Thomas, Sales Engr., William A. DaLee, Inc., Detroit, Mich.

THERE are two main classifications of deep well turbine pumps: those with water-lubricated and those with oil-lubricated line shaft bearings. Sub-classifications of both types depend upon the use of open or closed impellers. The drives for these pumps may be either electric motors, gasoline engines or combinations of the two.

Adjustment

There are only two adjustments possible on a deep well turbine, impeller adjustment and packing gland adjustment. Impeller adjustments are always made in accordance with manufacturers' recommendations. As the proper setting of impellers can vitally affect the performance and wear of both the impeller and the pump bowls, adjustment must take into account such important factors as total head, capacity, speed and shaft diameter. Only on water-lubricated turbines can a packing gland problem be readily handled without disturbing the pump. The packing gland must be so adjusted that there is some weepage to cool and lubricate the bearing point. The packing gland at the bottom of an oil-lubricated turbine cannot be adjusted while in service.

Lubrication

There are four chief points of lubrication in deep well turbines: the motor,

the packing gland, the line shaft bearing and the pump bowl bearings.

1. *Motor.* The motors of deep well pumps are usually lubricated by oil or grease, sometimes both. In lubricating it is well to follow the motor manufacturer's recommendations very carefully. Most motors are equipped with ball thrust and steady bearings which, if oil-lubricated, must be periodically flushed out before the oil is renewed. This can be done with carbon tetrachloride and flushing oil; the reservoirs can then be filled with clean, new oil. Care must be taken at all times never to allow dirt or grit to enter the bearings. With grease-lubricated bearings, the relief plug should always be removed when grease is forced into the grease fitting, and the grease pumped until clean grease comes out of the relief plug opening. The motor is then run for a few minutes before the plug is replaced. It is not usually necessary to lubricate the motor more than once a year. The motor should never be overgreased.

2. *Packing Gland.* There are two sources of lubrication in the packing gland of a water-lubricated turbine. One is a grease line, which usually enters below the packing box, filling the stilling well with a special grease to prevent water from coming up along the shaft in full force. The force of the water pressure in the column tends

to press the grease into the packing box. If the packing is properly adjusted, some water weepage is permitted to pass the gland, thus providing the second source of lubrication for the shaft at this point.

3. *Line Shaft Bearings.* The water-lubricated deep well turbine is self-lubricated at all times, except before operation. For this lubrication, a constant small stream of water should be allowed to run down the shaft to keep the rubber bearings wet, or a timing device on the motor starter should be provided to allow a minute or so of lubrication prior to starting the pump. This preliminary lubrication keeps the bearings from running dry for even a short time; dry bearings become heated and the rubber will adhere to the shafting and seize the bearing. In oil-lubricated deep well turbines, the oil enclosing tube must be free from holes and the lower packing gland must be reasonably tight. Otherwise, water will be forced up into the space between the shaft and the oil-enclosing tube to form an emulsion which is damaging to the bearings. Oilers must be adjusted to apply the proper number of drops per minute of the proper lubricant in accordance with manufacturer's recommendations. A solenoid oiler should be used to prevent the oil from running into the pump when the pump is not in operation. Too much oil in the enclosing tube, when mixed with water, can cause overloading of the small pump motors.

4. *Pump Bowl Bearings.* No matter how the line shaft bearings may be lubricated, pump bowl bearings, whether metal or rubber, can be lubricated only by water.

Inspection

The pump assembly should be periodically checked—from once a day to

once a week, depending on the service required. It is desirable to have the same person make the checks each time so that any changes in the sound made by the equipment can be detected. The temperature of the bearings should be checked, and is usually appraised by feeling the motor and packing gland. If the motor or bearings run hot, the unit should be checked more thoroughly. The sound of the motor on starting, at full running speed, and on stopping should be listened to with a critical ear. If the nonreverse ratchets are worn they will cause a great deal more noise than usual on starting or stopping. Excessive leakage at the packing gland should be checked and corrected, either by complete replacement of the packing rings or tightening of the gland. Pump production should be checked to see whether the capacity is up to normal, and the drawdown gage should be examined to see whether or not the static and pumping levels are normal. A good maintenance man or factory representative should check the unit either annually or semiannually to correct any difficulties. A complete mechanical inspection must also be made every few years.

Repairs

Although repairs are usually needed before a pump is put out of service, every effort should be made to anticipate impending difficulties so that damage may be forestalled. Obviously, when a pump is out of service, repairs are mandatory. The question of how far to carry them then becomes an important one. Often a pump is quite old and repairs so expensive that they are not economically justifiable. Many pumps badly in need of repair can be given emergency repairs which will hold them together for months or even years. The efficiency which can be

achieved, however, is usually so low that subsequent operation is unjustifiably expensive.

Prevention of Failure

Motor failures usually involve one of the following parts:

1. *Nonreverse Ratchet.* Failure of nonreverse ratchets is due to attempted lubrication, operation at extremely high heads or improper design of the pins and ratchet face.

2. *Motor Bearings.* Failure of motor bearings is generally caused by improper lubrication, ordinary wear, dirt or failure of the water slinger to keep water out of the bearings.

3. *Windings.* Windings seldom fail, but when they do it is because of overheating or moisture.

4. *Starter.* Because the starter and the starter control are subject to many operating troubles, they should be checked by an electrician or by the manufacturer.

Pump failures usually involve the following parts:

1. *Packing Gland.* Packing gland failures are caused by normal wear, sanding, lack of a stilling tube, the use of improper packing material or failure to replace the complete packing during renewal.

2. *Drive Shaft.* Drive shaft failures are caused by corrosion, sanding or faulty bearings.

3. *Bearings.* Bearings fail because of improper lubrication or sanding.

4. *Impellers and Bowl Seat.* Failures of impellers and bowl seat are caused by improper setting of the pump, graphiting or sanding.

5. *Pump Column.* Pump column failure is usually caused by corrosion from electrolysis or corrosive water.

Maintenance Program

A positive maintenance program such as the one outlined below is very effective in preventing shutdowns:

Daily inspections should be made of pump operation; annual checks of pump construction and performance are also important.

Standard operating procedures for lubrication should be followed and responsibility delegated for the selection of lubricants and the performance of lubricating duties.

Spare parts for emergency repairs should be kept on hand. It is wise to consult the manufacturer for information on such equipment.

Complete physical inspection of the pumps should be made at five-, seven-, or ten-year intervals. To permit such inspection, the pump must be removed at a slack period. This requires either large water storage or a standby pump and well that can be used during the inspection period.

The drawdown gage and main-pump meter should be observed regularly and results compared with new pump performance. A chart recorder for both sets of data is desirable as impending failure is usually indicated well in advance.

Any unusual noise, leakage or lack of oil consumption on an oil-lubricated pump or change in operating conditions should not be permitted to continue without immediate investigation and repair.

Water Fluoridation—A Sound Public Health Practice

By Charles R. Cox and David B. Ast

A contribution to the Journal by Charles R. Cox, Chief, Water Supply Section, Bureau of Environmental San., and David B. Ast, Director, Bureau of Dental Health; both of the State Dept. of Health, Albany, N.Y.

THE benefits which accrue to the public from the sanitary quality of potable water are taken for granted today. Yet the dramatic reduction in morbidity and mortality from water-borne diseases is not a mere coincidence, but is the result of the progress made in water sanitation. The reduction of typhoid fever mortality within the lifetime of the present generation, in New York State, for example, from 10 per 100,000 population in 1920 to no deaths at all from typhoid fever in 1950, is certainly evidence of the sanitary engineer's contribution to good health.

Another Health Program

Within the past decade, the water engineer has been asked to participate in another type of health program. This program requires him to maintain what is considered today to be the optimum concentration of an element found naturally in varying concentrations in water supplies. This element is fluorine, which exerts a protective influence against dental caries.

The disclosure that disfiguring mottled enamel of the teeth is due to the natural presence of more than 1.5 ppm. of fluorine in the waters used by those so affected, resulted in the analysis of many natural waters to determine their fluoride ion content. The presence of fluorides in natural waters is associated

with igneous rocks and with prior volcanic action, or with sedimentary rocks which have been influenced by the weathering of igneous rocks. Fluorides are therefore most likely to be present in ground waters mineralized by sandstone and limestone formations. The fluorides in rocks are largely insoluble, so the concentration of soluble fluorides present in natural waters almost never exceeds 15.0 ppm. and is usually less than 1.0 ppm. Naturally occurring soluble fluorides are similar in chemical composition to the fluoride compounds being added to public water supplies in fluoridation treatment.

A study of the distribution of fluoride-bearing waters by Hill, Jelinek and Blayney (1) discloses that natural waters in the 32 states investigated usually contained low concentrations of fluorides, but that many natural waters—mostly located in Ohio, Indiana, Illinois, South Dakota and Texas—contained concentrations of fluoride ion greater than 1.0 ppm. The survey discloses that approximately 3,000,000 people are served by water supplies containing from 1.0 ppm. fluoride ion to more than 5.0 ppm. as shown in Table 1.

Fluoride Ion Removal

Efforts have been made in the past to remove the fluoride ion from public water supplies when present in con-

centrations in excess of 1.5 ppm. This figure represents the permissible limit of fluorine in potable water, as established by the Drinking Water Standards of the U.S. Public Health Service (2). Such treatment represents a logical aspect of water treatment practice designed to produce a potable water containing the desirable concentration of fluoride ion when originally present in excessive concentrations.

The same end is accomplished by the addition of a fluoride compound to those natural waters containing a lower concentration of fluorine than dental surveys have indicated to be desirable. This method was the basis of the pio-

a total population of nearly 6,000,000, including that of Milwaukee, has been approved. Fluoridation is also under consideration at 167 supplies, including those of New York City and Chicago. The total population which will be benefited by all of these programs will exceed 20,000,000.

Growth of Public Interest

It is very evident that this great growth of interest in water fluoridation results from public recognition of the prevalence of dental caries, and realization that protective measures can be taken on a community-wide basis through the treatment of the public water supply, so that ultimately the whole community will benefit. Such community-wide action is typical of other practices in the field of environmental sanitation, such as the installation of water purification equipment to reduce waterborne diseases, which benefits all consumers of water without the need of individual participation. Water fluoridation is therefore an extension of standardized water treatment procedures designed to improve the health of the consumers.

This treatment procedure is subject to general supervision and control by health departments in a manner long established by practice. The type of equipment employed is identical with that heretofore used in the application of other water treatment chemicals. Laboratory control procedures for fluoridation are also similar in principle to those highly standardized in the control of water chlorination. The qualifications of operators responsible for the control of water fluoridation equipment are similar to those governing the qualifications of water chlorination plant operators.

The cost of fluoridation, 5-15¢ per capita per year, is moderate. As a reg-

TABLE 1

Population in 32 States Served by Public Water Supplies Naturally Containing More Than 1.0 ppm. Fluoride Ion

Approx. Population Served	Fluoride Ion Content ppm.
1,000,000	1.0-1.5
900,000	1.6-2.0
600,000	2.1-3.0
100,000	3.1-5.0
40,000	5.1 or higher

neer fluoridation programs at Newburgh, N.Y.; Grand Rapids, Mich.; and Brantford, Ont., in 1945—an increase in the fluoride ion content of these supplies to 1.0-1.2 ppm. This is the concentration found to be so beneficial when present naturally, as in the water supply of Aurora, Ill. Eleven demonstrations of water fluoridation were in progress in the United States and Canada by 1949, and 6 supplies were also being fluoridated as a routine procedure. The favorable results of the demonstrations, to be discussed later, have now led to the fluoridation of 82 supplies in 21 states, serving a total population of 1,700,000. The fluoridation of 95 additional supplies serving

ular expense it can readily be integrated into charges for water services, so that the consumers who benefit will absorb the added cost. This procedure has met with the approval of the public service commissions of several states.

Not Harmful

The presence of 1.0-1.2 ppm. fluoride ion in water is not detrimental either to domestic or industrial consumers. No deleterious effects from the presence of fluoride ion in water, other than mottling of the tooth enamel, have become apparent in the numerous communities studied which are served with waters naturally containing concentrations of fluoride ion in excess of 1.0 ppm.

The same favorable situation prevails in communities served waters treated to have the optimum fluorine concentration of about 1.0 ppm. Many industries are located in these communities, including chemical industries, breweries, bakeries and soft drink bottling plants, for which water quality is important. No unfavorable effects upon industrial processes have been reported, except that ice made from fluoridated water in Charlotte, N.C., was "brittle." No such effect has been reported from the other communities where ice is manufactured and served by water supplies containing 1.0 ppm. or more fluoride ion concentration.

Fluoride compounds have been handled in the chemical industry without any difficulty as long as dust is minimized and ordinary precautions are taken by using dust respirators and rubber gloves. No occupational hazard has been disclosed in the handling of fluoride compounds at water treatment plants provided dust control equipment is used and dust respirators and rubber gloves are worn by those handling the solid fluoride compounds.

Mode of Operation

Although it is not clearly understood how ingested fluoride acts to protect the teeth against dental caries, there are some hypotheses which merit consideration. The evidence obtained from studies in areas where waters naturally contain fluorides and areas where controlled fluoridation is currently being studied indicate that the greatest benefits from ingested waterborne fluorides accrue during the years of enamel development and calcification—through age eight except for third molars. This disclosure suggests a physiological action in which the fluoride ion is incorporated into the enamel, making the enamel harder and more resistant to acid decalcification. It is also known that fluorine is an enzyme inhibitor and may therefore interfere with enzymatic processes necessary for organic acid production in the mouth.

Benefits from ingested fluorides have been noted among children even when taken after enamel calcification and eruption of teeth. This manifestation suggests possible benefits from frequent bathing of the teeth by the fluoridated water. It is believed that the fluoride is adsorbed on the surface of the teeth with the same beneficial effects.

Although it is well known that the potable water intake of individuals varies, it is estimated that a reasonable average would be 1-1½ l. per day. At 1-1.2 ppm. F, this would account for 1-1.5 mg. F ingested from this source daily. McClure (3) studied the F content of foods and reported that all contain traces of fluorine. The daily intake from this source is negligible, however, varying from 0.19-0.32 mg.

Fluorine Toxicity

Considerable study has been given to the systemic effects of fluorine, other

than on the teeth. These investigations are still under way. It is therefore pertinent to present briefly what is known about the toxicity of fluorine. There is no possible danger of acute fluorine poisoning from waterborne fluorides. The lethal dose of sodium fluoride has been estimated by Roholm (4) to be 4 g.

Acute morbidity, manifested by increased salivation and vomiting, may be caused by 0.25 g. sodium fluoride. This quantity in an 8-oz. glass of water represents 1,000 ppm. sodium fluoride, or about 450 ppm. fluorine. To obtain this concentration, it would require more than four tons of sodium fluoride per mil.gal. of water treated, which is obviously not possible in a program of water fluoridation, even if gross negligence occurred.

The literature on chronic fluorine toxicity is quite extensive. Cox and Hodge (5) have summarized both acute and chronic toxicity, and this information may be used to good advantage as a reference.

Elimination of Fluorine

Studies in the retention of appreciable amounts of fluoride indicate that the body has a very efficient mechanism to eliminate fluoride through urine, sweat and feces. McClure (3) has estimated that at least 90 per cent of ingested fluorides, as much as 3-4 mg. daily, are eliminated through these means.

McClure (3) also studied the relationship of ingested waterborne fluorides to height, weight and bone fracture experience among large numbers of high school boys and young men who were examined for selective service, and was unable to find any differences between men coming from fluoride and fluoride-free areas.

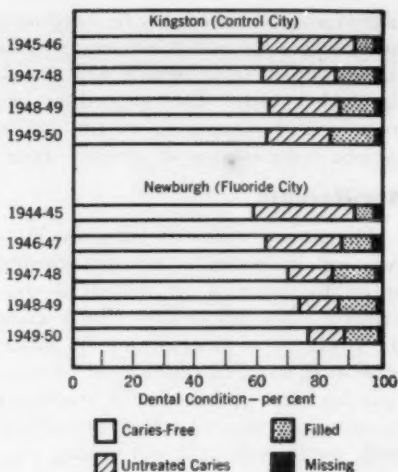


Fig. 1. Clinical Status of Erupted First Permanent Molars of Children Ages 6-9

The number of first permanent molars filled and the correction services are in about the same proportion in each city. The improvement in Newburgh in the number of untreated carious teeth was almost double that of Kingston.

Newburgh-Kingston Demonstration

In the Newburgh-Kingston demonstration (6, 7), comprehensive medical and laboratory study is being given to possible effects of ingested fluoride on tissues and organs other than teeth. These examinations include a general physical examination, blood and urine analyses, X-rays of hands, forearms and tibias, and special eye and ear examinations. No differences have yet been noted among the children thus examined in Newburgh, the study city, and Kingston, the control city.

There is perhaps no health technique which has had as intensive and comprehensive study prior to its general application as water fluoridation. A review of the newer public health practices and therapeutic uses of new drugs

TABLE 2

*Clinical Status of Erupted First Permanent
of 6-9-Year-Old Children*

Year	No. Molars	Proportion—per cent			
		Caries Free	De- cayed	Filled	Missing
<i>Newburgh (fluoride city)</i>					
1944-5	5463	58.9	32.7	7.4	1.0
1946-7	5031	63.2	23.8	11.8	1.1
1947-8	4798	70.0	13.8	15.0	1.3
1948-9	5262	73.9	11.9	13.6	0.5
1949-50	5274	76.9	10.4	12.3	0.4
<i>Kingston (control city)</i>					
1945-6	5066	60.5	30.7	7.2	1.7
1947	5058	61.3	23.8	13.2	1.7
1948	5303	63.7	22.6	12.3	1.3
1949	5300	63.6	19.6	15.6	1.3

reveals no such study, especially on human beings, before they were recommended for general application.

Some questions have been raised concerning the advisability of fluoridating a communal water supply because of the objection to so-called medication of water supplies. The control of the optimum concentration of a constituent found naturally in drinking water cannot be considered as medication in the sense of adding a new chemical to water as a therapeutic agent. As pointed out previously, reducing excess fluoride down to the optimum concentration is, in principle, the same as increasing the concentration to the optimum level.

Cost Factors

The objection to water fluoridation because less than 1 per cent of the treated water is consumed for potable purposes would be serious if the costs were appreciable. The moderate 5-15¢ per capita per year cost for the

total community population, or 25-75¢ per child per year, is much less than the cost of any other suggested prophylactic technique. The cost is certainly considerably less than that of correcting dental defects. It is reasonable to base the cost on the total population, since the protected children grow into protected adults.

Alternative Media

The suggestion that a fluoride compound should be added to some food products in preference to water is not feasible. The consumption of any given food, including milk, is not universal, nor sufficiently constant to assure the benefits known to accrue from fluoridation. On the other hand, even breast-fed babies drink water.

Table salt is another suggested fluorine medium, but infants and young children do not ordinarily use table salt, and it is in these age groups that ingested fluorides are so important for dental health. The task of the addition of fluorides to food would also be impracticable because of the diversity of source and complexity in their handling and marketing.

Dental Findings

A number of studies in widely separated areas in the United States have been made since 1945 on the effects of controlling the fluorine concentration of potable water supplies at approximately 1.0 ppm. to prevent dental caries. Seven of these areas have already reported benefits of varying degrees, depending on the length of exposure to waters fluoridated at the optimum concentrations of 1.0 to 1.2 ppm.

To single out two of the progress reports in which controlled fluoridation has been under way longest—in Newburgh, N.Y., and Grand Rapids, Mich.

—it is noted that the benefits are quite impressive. In Newburgh the fluoride ion concentration has been increased from 0.05–0.15 ppm. in the raw water to 1.2 ppm. F in the distribution system, and there has been a 32.5 per cent reduction in the DMF* rates among 6–12-year-old children after four years of experience. With fluorine-free water, there was no reduction in Kingston,

with all deciduous teeth completely caries-free.†

Of special interest is the comparison of the clinical findings in the permanent first molars of the 6–9-year-old children in Newburgh with the same age group in Kingston. The clinical examination revealed that the number of first permanent molars filled in this age group in each city increased in about the same

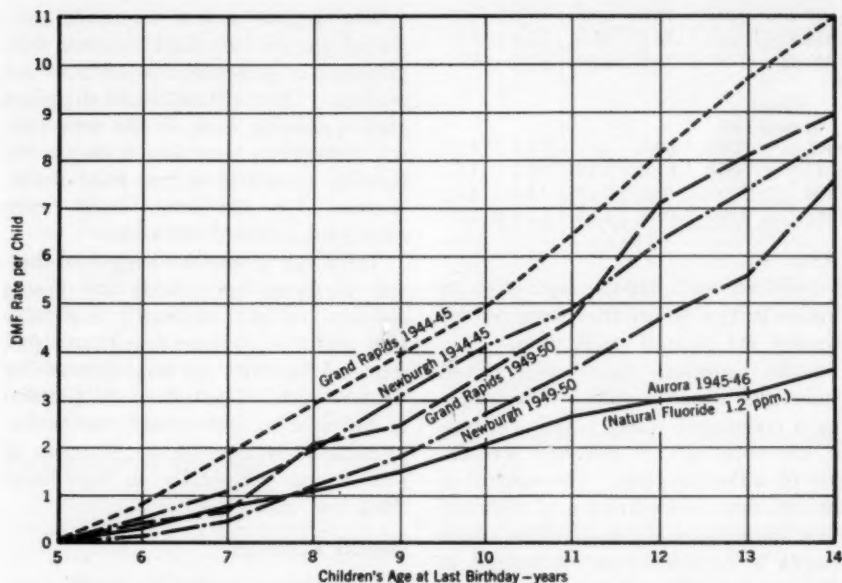


Fig. 2. Permanent Teeth per Child in Controlled and Natural Fluoride Areas

The Newburgh and Grand Rapids data for the years 1944–50 are plotted against the DMF rates in Aurora, Ill., a community with a natural concentration of 1.2 ppm. fluoride in its water.

the control city, in the overall DMF rates for the same age group. The greatest benefits were noted among younger children. Among the 5- and 6-year-olds, there was an increase of 115 per cent in the number of children

proportion annually, and that the correction services are comparable in both cities. The number of extracted first permanent molars decreased from a high of 1.3 per 100 to 0.4 per 100 in Newburgh. In Kingston the difference was from 1.7 to 1.3 per 100. The pro-

* This is the symbol used to denote dental caries experience and represents the total number of permanent teeth decayed, missing and filled.

† Children with all of their deciduous cuspid and deciduous molar teeth present and caries-free were considered caries-free.

portion of untreated carious teeth (the unmet needs) in Newburgh was however, 68 per cent less, or almost twice the improvement found in Kingston. This information is graphically represented in Fig. 1. This condition leads to the speculation that if this downward trend in unmet needs continues, dental caries occurrence may be reduced so that the present complement of local dentists will be able to exercise adequate control and thereby reduce tooth mortality from caries to almost none.

TABLE 3

DMF Teeth per Child in Controlled and Natural Fluoride Areas

Age years	Controlled Areas				Natural Area
	Newburgh		Grand Rapids		Aurora
	1944-45*	1949-50	1944-45*	1949-50	
5	0.18	0.02	0.11	0.03	0.06
6	0.48	0.11	0.78	0.38	0.28
7	1.05	0.47	1.89	0.76	0.70
8	1.95	1.16	2.94	2.16	1.04
9	3.11	1.88	3.90	2.48	1.52
10	4.01	2.74	4.92	3.56	2.02
11	4.84	3.59	6.41	4.69	2.67
12	6.36	4.73	8.07	7.02	2.95
13	7.43	5.66	9.73	8.11	3.09
14	8.50	7.62	10.94	8.90	3.64

* Before addition of sodium fluoride.

Comparison With Midwest

In Grand Rapids, after five years of experience, a reduction of 51.3 per cent in DMF teeth per 100 children at age 6 is noted, 36.4 per cent at age 9 and 16.7 per cent at age 13. The Newburgh and Grand Rapids data are plotted against the DMF rates in Aurora, Ill., where the community drinking water naturally contains 1.2 ppm. F in Fig. 2. It is noted that in Grand Rapids, where the DMF rates were higher than in Newburgh in 1944-45,

the DMF rates in 1949-50 for children age 5-7 were comparable with those in Aurora. The Newburgh figures for 1949-50 show DMF rates below or equal to Aurora through age 8.

Equally encouraging published reports have come from Brantford, Ont., Evanston, Ill., and Sheboygan, Wis., where controlled fluoridation programs are under study.

Approval of Agencies

The agencies listed below have given their approval to water fluoridation:

1. American Assn. of Public Health Dentists
2. American Dental Assn.
3. American Public Health Assn.
4. American Water Works Assn.*
5. State and Territorial Dental Directors Assn.
6. State and Territorial Health Officers Assn.
7. The Conference of State Sanitary Engineers†
8. U.S. Public Health Service
9. Many state departments of health

Summary

At a conference held early in June 1951, the state dental directors met with representatives of the U.S. Public Health Service and the Children's Bureau to discuss, among other matters, the question of how to bring the benefits of water fluoridation to the attention of civil authorities and to motivate them to action. It was generally agreed that there are several important questions that the civic leaders should have answered.

* See p. 602 for statement of policy on fluoridation adopted by the Board of Directors of A.W.W.A.

† The Conference of State Sanitary Engineers in furtherance of the favorable policy of the State and Territorial Health Officers' Assn. developed, in May 1951, procedures for the control of fluoridation practice.

1. Will fluoridation do any good?
2. Will it do any harm?
3. What will it cost?

The reported data from areas where the communal water supply naturally contains the optimum concentration of fluoride, as well as from areas where controlled fluoridation is being practiced, amply demonstrate the benefits to dental health from this procedure.

No evidence of an adverse physiological affect on children or adults due to use of drinking water with a fluoride content of 1.5 ppm. or less has been found. McClure's studies (3) covered height, weight and bone fracture experience of young men examined for selective service. The Newburgh-Kingston study (6, 7) included general physical examinations; blood and urine analyses; X-rays of hands, forearms and tibias; and special eye and ear examinations of the children in both those cities.

The 5-15¢ per capita per year cost of water fluoridation is among the least expensive of public health practices today.

The health professions have today reached a new milestone in the progress of man over disease. If, through the relatively simple and inexpensive process of water fluoridation, an almost universal disease can be controlled, why delay any longer?

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The Ideal Lime-Softened Water

By T. E. Larson

A paper presented on March 29, 1951, at the Illinois Section Meeting, Chicago, by Thurston E. Larson, Head of the Chemistry Subdiv., State Water Survey, Urbana, Ill.

FROM time to time, the attention of the Illinois State Water Survey has been called to the problems of preventing scale and corrosion by lime-softened water, notwithstanding saturation and stability indexes. One operator concludes that when red water complaints equal scale complaints, he is doing the best in his power to produce an ideal water. This conclusion may be valid, but theory and evidence presented here may help to reduce the number of both types of complaints.

In order to establish a satisfactory basis for studying the extent of such difficulties, a questionnaire on scale and corrosion problems was sent to 36 municipalities that use lime-softened water. There were received 21 replies, 9 samples of treated water for analysis (5 other replies provided analyses), and 10 scale samples from hot- and cold-water lines.

The data obtained offered an approach to determining the composition of an ideal, noncorrosive and nonscale-forming water. This evidence is particularly applicable as it was collected in the form of field surveys under actual operating conditions.

Magnesium Hydroxide Scale

It was found that in seven of the plants listed in Table 1, the scale from the hot-water tanks or the deposits in

hot-water lines were composed largely of magnesium hydroxide with an appreciable proportion of silica. In five of these plants, little or no calcium carbonate was present. In one plant, magnesium hydroxide, as well as calcium carbonate, was found in a cold-water line deposit (Table 2).

On the basis of published data by Ryznar, Green and Winterstein (1) and various other authors who have reported the solubility product of magnesium hydroxide and its change with temperature, it was found difficult to determine the reason for the high magnesium concentrations present in the scales examined. A review of the literature offered no satisfactory explanation, possibly because the laboratory determination of the solubility product constant is rather difficult, or because certain factors in the design and operation of the particular heaters made the data inapplicable. It was therefore decided to use the actual data collected in this study to determine the experienced magnesium solubility at hot-water tank temperatures and operating conditions.

The pertinent basic data collected on water quality and scale formation are shown in Fig. 1. The water quality at plants from which no scale samples were submitted are included, and it is assumed that there was little or no

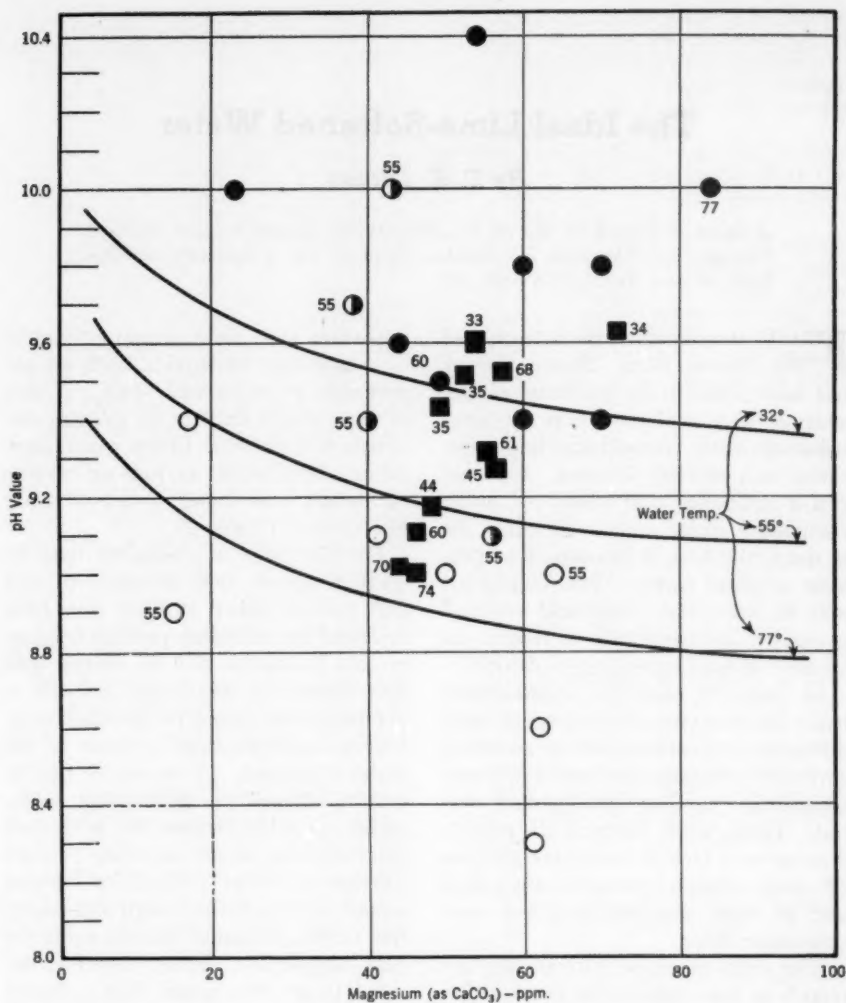


Fig. 1. Magnesium Solubility at Hot Water Tank Temperatures

At the indicated plant effluent temperature, if the magnesium content of the water is greater than indicated by the temperature curve at a given pH, magnesium hydroxide deposits may be expected.

Key

- $Mg(OH)_2$ present in scale
 - No scale samples submitted
 - ◐ $Mg(OH)_2$ always present (Plant N) (Alkalinity 170 ppm.)
 - ◑ $Mg(OH)_2$ always present (Plant G)
- Numbers represent temperatures of water at time of pH measurements. Curves are adjusted to satisfy solubility product relationship.

TABLE 1
Water Analyses

Plant	Alkalinity		Hardness		SiO ₂	pH	D.O.
	Phenolphthalein	Methyl Orange	Mg	Ca			
	(ppm. as CaCO ₃)				ppm.		ppm.
A	6	30	15	38.0	14.4	8.9	
B	10	22	50	40.0		9.0	++
C	4	56	61	57.0	14.4	8.3	
D	30	60	60-70	40.0-50.0	6.0-10.0	9.4-9.8	10.0
E	8	76	62	56.0	10.1	8.6	
F	58	134	84	7.5	13.0	10.0	+
G	9	36	45	55.0	5.5	9.3	++
H	15	32	17	15.0	9.0	9.4	6.2-9.7
I		28	44	41.0	6.1	(9.6)	++
J	27	56	23	7.2	5.0	10.0-11.0	0-8.0
K	10	36	41	50.0	15.0	9.1	
L	19	34	54	35.0	12.6	10.4	3.0-17.0
M	8	44	64	66.0	11.7	9.0	
N	24	168	56	26.0	17.6	9.1	
N		170	40	29.0		9.4	
N		174	43	29.0		10.0	
N		202	55	60.0		9.1	
N		166	38	40.0		9.7	

difficulty with hot-water scale. The alkalinity of most of these waters ranged from 20 to 50 ppm.

Three solubility curves have been fitted to these data, each for a different temperature. These curves correspond to the normal magnesium hydroxide solubility relationship:

$$(\text{Mg}) \times (\text{OH})^2 = K_{\text{Mg}(\text{OH})_2}$$

It should be of interest to note that these data correspond quite well with those at 176°F. as provided but not used, in Table 4 in the paper by Ryznar, Green and Winterstein (1). Figure 1 shows that, at the indicated plant effluent temperature, if the magnesium content of the water is greater than that indicated by the temperature curve at a given pH, magnesium hydroxide deposits might be expected in some hot-water systems.

This principle does not mean that all hot-water tanks will be troubled with deposits. Much depends on the design and the manner of operation. Factors such as retention period, rate of heat input and temperature of effluent are of particular importance.

Polyphosphates

Although the use of polyphosphates has often proved effective in preventing CaCO₃ scale formation, it is well established (2) that its use for corrosion control has had conflicting results. Two reasons may be cited.

1. The anticorrosive action of polyphosphates depends so greatly on an appreciable rate of flow that it is impractical to use them effectively at treatment plants for hot-water tank protection and at other points of low linear flow.

2. The rate of reversion to orthophosphate (3, 4, 5) is often so great at high pH and high temperatures, that the increase in hydrogen ion, as well as the increase in orthophosphate, tends to nullify any corrosion or scale inhibition that the remaining polyphosphate may provide.

It appears that low-concentration polyphosphates have been used almost entirely to prevent calcium deposits. The relative value of each of the poly-

cium carbonate (at high temperatures and at high pH), there is some rather inconclusive evidence that specific, less publicized polyphosphates may have a strong tendency to inhibit magnesium hydroxide incrustation.

Theory

In any discussion of scale prevention it is pertinent to refer to the intentional formation of a thin, dense, eggshell scale to prevent corrosion.

TABLE 2
Scale Analysis

Plant	Temp. of Use	CaO	CaO ₂	MgO	SiO ₂	P ₂ O ₅	Fe ₂ O ₃	Al ₂ O ₃	SO ₃	Loss on Ignition
		<i>per cent</i>								
D	cold	24.2	18.0	18.8	19.7	1.1	10.3			6.6
F*	hot	5.1	5.7	70.0	17.5	0.0	1.8			
G*	hot	1.8	4.5	32.9	18.2	0.0	0.3	17.3		
I	cold	43.8	32.4	5.7	5.2	0.0	1.1	3.5	0.34	7.8
I*	hot	6.7	5.7	46.0	37.4	0.0	2.6	2.6	0.0	
J	hot	46.9	4.7	10.8	2.8	31.3†	4.6			
K	cold	1.0	4.1	6.6	11.4	2.1	64.4‡		2.3	9.3
K	hot	8.3	1.9	46.2	24.8		0.0			
L	hot§	3.8		34.2	28.1			2.8		
N	hot	26.9	27.8	20.6	1.7	2.6				0.6

* Dry basis.

† Micromet, a product of Calgon, Inc., Pittsburgh, Pa., being applied.

‡ Sample from 4-in. main in use before treatment period started (raw water had 4.0 ppm. Fe).

§ Analysis by Dept. of Public Health.

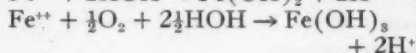
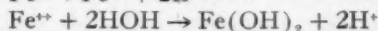
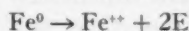
|| Analysis by National Aluminate Corp., Chicago, Ill.

phosphates should be studied for use with different waters and for different purposes, as there is evidence that the addition of certain polyphosphates can increase the corrosion rate in hot-water tanks. There is also evidence that tricalcium phosphate precipitation can take place in hot-water tanks in the form of a light, fluffy, soft scale deposit.

Although, to the author's knowledge, no polyphosphate has yet been reported that inhibits the deposition of magnesium hydroxide in addition to cal-

The process of underwater corrosion requires the presence of anodic and cathodic areas.

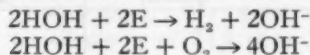
Of fundamental importance is the anodic reaction. Hydrogen ions are produced at the anode, particularly in the presence of dissolved oxygen, since ferric hydroxide is considerably less soluble than ferrous hydroxide.



Such acidity as that produced at the anode, when cumulative in pits, accelerates corrosion, particularly when accompanied by chloride and sulfate ions resulting from the mobility of these negative ions toward the anode. It is therefore evident that a desirable water should have a high proportion of negative carbonate and bicarbonate ions (alkalinity) to buffer or absorb the hydrogen ions (H_2CO_3) and to reduce the tendency toward the accumulation of a strong acid in these pits.

Hydroxyl Ion Formation

Of equally fundamental importance is the formation of hydroxyl ions at the cathode, whether dissolved oxygen is present or hydrogen gas is produced.



Thus a nearly stable water (0 to + saturation index) offers a basic condition under which calcium carbonate can be deposited at one of the two electrodes necessary for corrosion to take place. On the premise that a controlled scale will reduce corrosion, a potential or slight actual deposition of this type is desirable. On the deposition, insulation is provided at the electrode, thereby reducing the current flow and, consequently, the corrosive action. The production of hydroxyl ions per unit of electrical current generated by the corrosion process is greater in the presence than in the absence of dissolved oxygen.

Calcium Carbonate Stability

Since this theory of corrosion prevention involves the saturation index, a number of facts concerning calcium carbonate stability are worthy of mention. No author (1, 6-12) writing on the subject of calcium carbonate stability has indicated that this is a simple,

final solution to scale and corrosion prevention. It is, however, a widely used tool and constitutes a distinct improvement over the old hit-or-miss methods. A pointed discussion of this subject is again timely.

Some explanation of terms might be helpful:

The value of pH_s equals the pH at CaCO_3 saturation for a given calcium and alkalinity concentration.

$$I = \text{pH}_a - \text{pH}_s$$

If I is +, water is supersaturated; if I is minus, water is undersaturated.

1. The precipitation, or scale-forming tendency, will depend on the excess quantity of calcium carbonate in the water. At low pH values, the supersaturation (potential excess) of CaCO_3 per unit saturation index is much greater than at higher pH values. For example, for a +0.1 saturation index, the rate or tendency for scaling will be three times as great at pH 8.2 (6 ppm. excess CaCO_3) as at pH 9.2 (2 ppm. excess CaCO_3).

2. In the production of a stable water, it should be necessary to maintain an appreciable calcium hardness and alkalinity. The calcium hardness and the alkalinity (both expressed as calcium carbonate) should also be approximately equal. When either the calcium hardness or the alkalinity is equal to or approaches zero, little or no protecting scale can be expected.

When it is recognized that a low calcium hardness or low alkalinity requires a high saturation pH, it is obvious that the stability index (9) is a measure of this factor as well as the saturation index. The stability index may therefore often be a rough indicator of corrosive or scale-forming tendencies and is possibly more applicable

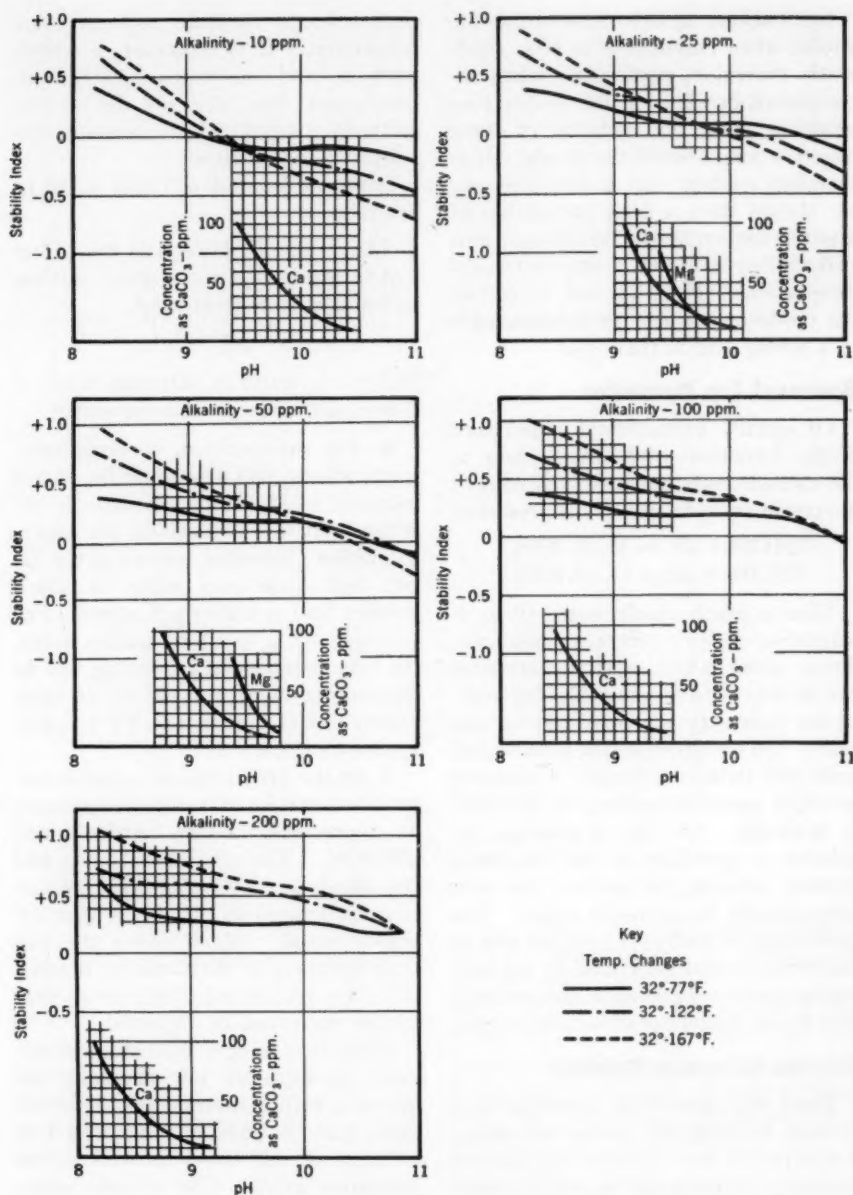


Fig. 2. Effect of Temperature Changes on Saturation Index

The curves show calcium solubility at 32° F. and the maximum magnesium solubility limit at hot-water tank temperatures.

than the saturation index. It is not a precise tool, however, and, with proper recognition of fundamentals in applying the saturation index, the latter appears to be preferable.

3. If the pH of the water tends toward hydroxide in the bicarbonate-carbonate-hydroxide equilibrium, any localized increase in hydroxyl ion by corrosion will not provide as great an increase or excess in CO_3 ion as would take place if the pH tended toward bicarbonate.

A water having an alkalinity of 24.8 ppm. and a pH of 10.28, for example, would have a carbonate ion concentration of 9.6 ppm. An increase in alkalinity by 1 ppm. hydroxyl ion would increase the carbonate ion concentration by 0.35 ppm. The same water with an alkalinity of 24.8 ppm. alkalinity but a pH of 9.78 ppm. would also have a carbonate ion concentration of 9.6 ppm. If the total alkalinity were again increased by 1 ppm. hydroxyl ion, the resultant carbonate ion increase would be 1.0 ppm. or approximately three times the original increase. It should be noted that both saturation indexes would increase locally by 0.016 units.

In the high pH range, therefore, the water with the lower pH, but the same carbonate ion concentration, would have a greater tendency to precipitate calcium carbonate at a cathodic corrosion area than the water at the higher saturation pH.

4. The removal of hydroxyl ions in hot water by precipitation with magnesium can invalidate a theoretically positive saturation index at the higher temperature. This reduction in alkalinity causes an excessive reduction in the actual pH, and also an increase in the saturation pH.

5. This competition between magnesium and the bicarbonate-carbonate-hydroxide equilibrium for hydroxyl ions may result in a flocculent magnesium hydroxide deposit, or coprecipitation of magnesium hydroxide with calcium carbonate. With either result, the desired thin, dense corrosion-prevention film of calcium carbonate is not formed. The flocculent magnesium hydroxide with its absorbed silica also has a high insulating value and decreases the heating efficiency of heat-transfer surfaces.

6. A very important factor in providing a stable water involves the net effect of temperature changes on the saturation index. The data for this factor have been indicated adequately by Langelier (11) and are reproduced graphically in Figs. 2, 3 and 4. The observations listed below should be noted.

a. On heating water of low alkalinity and high pH, the saturation index decreases critically; that is, the actual pH decreases more than the saturation pH.

b. On cooling water of high alkalinity, the saturation index decreases. This decrease can occur at dead ends in winter and spring when using hard or soft ground water of appreciable alkalinity, and in summer and fall when using warm surface water. A 10–20°F. temperature change can take place in the distribution system.

c. The practical range of pH for the curves in Fig. 3 is indicated by the calcium solubility. A 55°F. water having an alkalinity of 50 ppm. and a pH of 10 would contain less than 5 ppm. calcium hardness (for a water of 400 ppm. total mineral content).

d. On warming higher alkalinity water with a low pH, a scale-forming tendency is indicated at elevated temperatures.

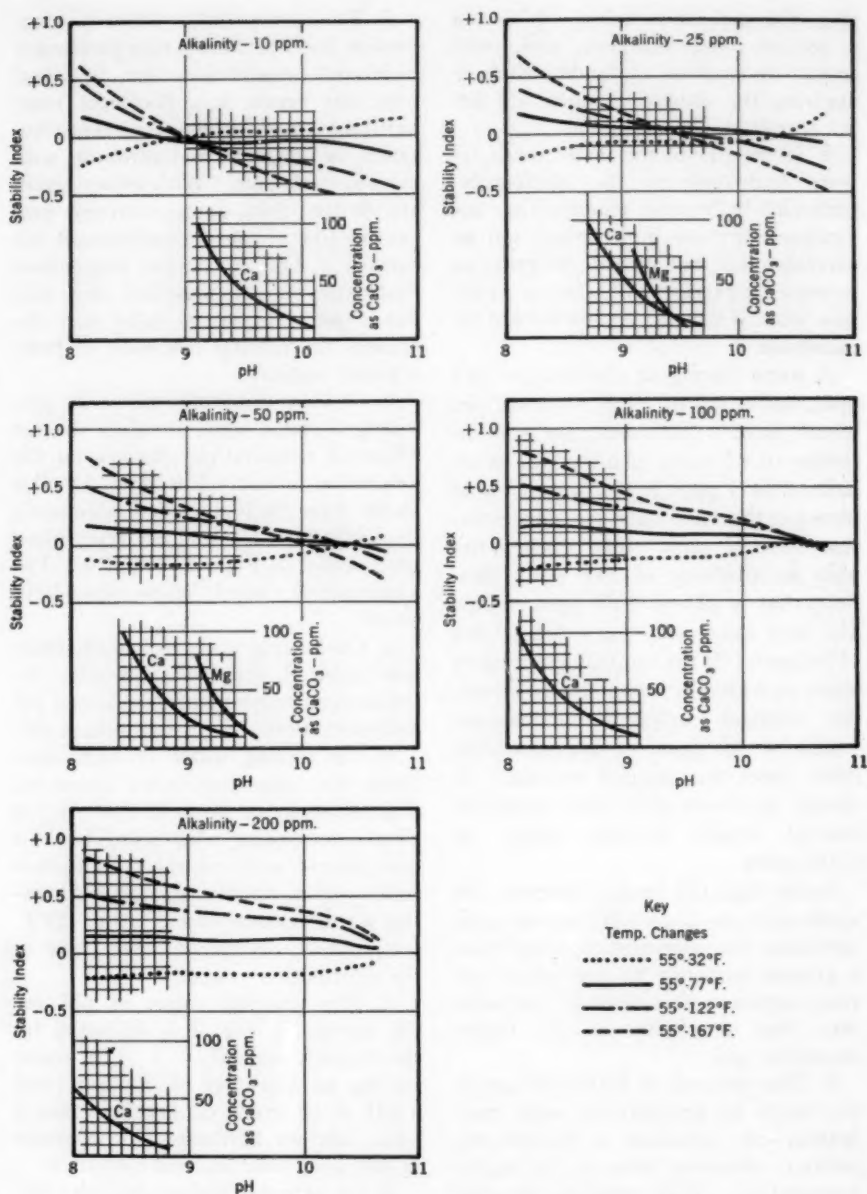


Fig. 3. Effect of Temperature Changes on Saturation Index

The curves show calcium solubility at 55° F. and the maximum magnesium solubility limit at hot-water tank temperatures.

e. The importance of an accurate pH determination is evident, since it can indicate erroneous scale-forming or corrosive tendencies with only a slight error. In order to utilize these data and interpolate between the figures, the pH must be carefully determined at the plant at the temperature of the water.

Each of these six factors must be given consideration in the production of an ideal water. The importance attached to each will depend on requirements for use and the facilities for treatment.

The Ideal Water

Any definition of an ideal water must be based on its intended use. For municipal supplies, such water is used for drinking, cooking, cleansing, sanitation and various industrial purposes.

The methods of production of safe, palatable, iron-free, soft water are well established, but subsequent effects of corrosion and incrustation during distribution often detract from the desirable qualities obtained at the treatment plant outlet. Distribution is here defined to go beyond the corporation cock through the service line to the household tap.

In order to provide a soft, nonincrusting, noncorrosive water, certain relative concentration limits must be maintained for several components.

From the saturation pH equation, it is evident that for any pH and alkalinity a specific calcium hardness is dictated that will maintain a 0 to + saturation index. For any alkalinity and hardness, a specific pH is likewise indicated. This pH can be calculated very rapidly and simply by means of the equations and data from two curves in Fig. 5.

To avoid nullification or cancellation of the benefits of this relationship, a

limit must be established for the magnesium content of the water at the pH under consideration. This limit is indicated by Fig. 1 and duplicated for the 25 and 50 ppm. alkalinity data in Figs. 2, 3 and 4. In utilizing these curves, the saturation pH is dictated by the calcium content and alkalinity. If it is desirable to provide water with a + index, the magnesium limit is dictated by the actual pH. The useful range of these data is dictated by the calcium hardness curves.

Design and Operation

Although the purpose of this presentation has been to outline the chemistry involved in the production and control of lime-soda softening, it also offers an opportunity for a chemist to add a few comments on design and operation. Both these factors are associated with economics, which it is simple for the chemist to ignore as being secondary to the production of a water that meets the demands of the consumer. When approached from the standpoint of proportional increase in either capital investment or cost per million gallons, this insurance against deterioration of underground investment and consumer good will is cheap.

The design features should include the necessary feeding equipment and controls to enable the operator to meet the necessary controlling limits outlined above. Proper balance of soda-ash, lime and recarbonation (or its equivalent) must be provided and maintained.

To produce the best water, this balance will depend upon the quality of the raw water in use. Two extremes may be cited:

1. A water having no alkalinity at a given hardness will require a maximum of soda ash in its treatment.

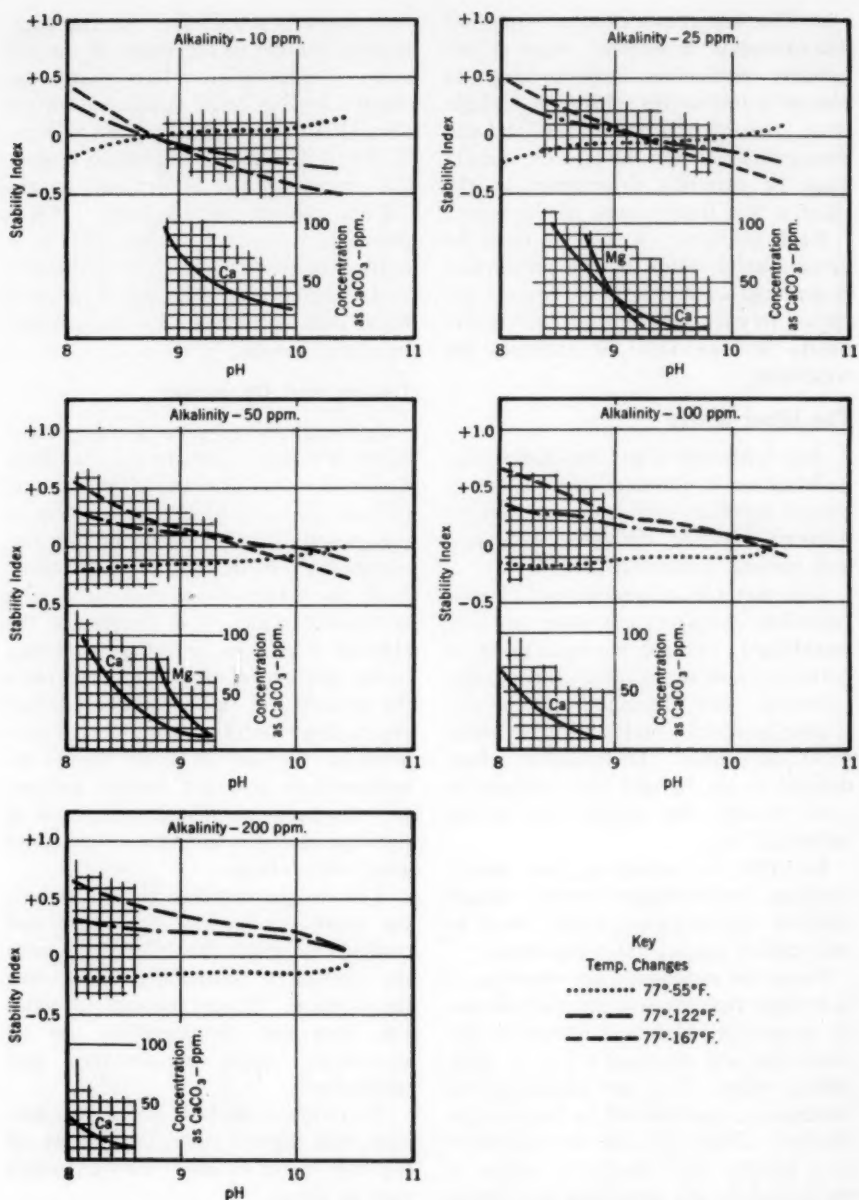


Fig. 4. Effect of Temperature Changes on Saturation Index

The curves show calcium solubility at 77° F. and the maximum magnesium solubility limit at hot-water tank temperatures.

2. A water having an alkalinity considerably in excess of this hardness will require no soda ash.

These principles are elementary, but between the two extremes lies the problem of design and operation. Both factors should be directed with sufficient flexibility to provide a resultant balance of alkalinity, calcium, pH and magnesium that will meet the desirable limits.

The necessity or advantages of ferric salts, alum or sodium aluminate for coagulation and more efficient magnesium removal should be weighed. The possible control (and cost) advantage of sulfuric acid to replace recarbonation should be considered for high alkalinity waters. If sludge volume is a critical factor, caustic soda may be an applicable, although costly, replacement for lime and soda ash. The advantages of split treatment should be considered, and the procurement of reliable controlled recarbonation for pH adjustment is a must. The possibility of overcarbonating before filtration, and later critically adjusting the pH with lime or soda ash, may provide better control of the effluent stability.

Plant G, mentioned in the opening paragraph, could be benefited by [1] treatment: with excess lime and recarbonation to convert calcium hydroxide to calcium bicarbonate; or [2] treatment with additional soda ash and recarbonation to a lower equilibrium pH. The former treatment offers magnesium removal as the effective result. The latter effects pH reduction with some sacrifice and loss in calcium hardness.

Choosing Optimum Water Quality

An outline of the procedure for choosing optimum water quality follows:

1. Determine Mg, Ca and alkalinity (as CaCO_3) in the treated water.

2. Calculate saturation pH for CaCO_3 at the temperature and total mineral content of water in use (Fig. 5).

3. Using these alkalinity and saturation pH values, interpolate between Fig. 2, 3 and 4 (a-d) to determine effect of temperature variations on the saturation index.

4. If saturation index decreases on anticipated temperature change, choose an actual pH for the plant effluent on temperature change high enough to keep the saturation index positive at the anticipated temperatures.

If saturation index increases on heating, careful and limited use of polyphosphate may be beneficial with a slight positive saturation index by reducing the tendency for excessive CaCO_3 deposition in the distribution system.

5. Note Mg solubility for hot water tanks at the chosen pH (Fig. 1). If the Mg present exceeds this value, reduce Mg content of water and again begin with step 1 above.

Magnesium reduction is facilitated by: [1] Na_2CO_3 (not definitely); [2] $\text{alum} + \text{Ca}(\text{OH})_2$; [3] alum and Na_2CO_3 ; [4] sodium aluminate; [5] $\text{Na}_2\text{CO}_3 + \text{Ca}(\text{OH})_2 \rightarrow \text{NaOH}$ (excess causticity); [6] split treatment or timed alternate treatment with over and under lime requirements (13); [7] excess $\text{Ca}(\text{OH})_2$ with recarbonation. (Each of the first five treatments will also reduce calcium, and possibly alkalinity, thereby requiring higher effluent pH.)

Summary

This review is concerned with changes in stability of water caused by temperature changes in distribution. An attempt has been made to define a range

of proper chemical balance which will minimize corrosion and incrustation complaints.

1. Theoretical and practical data are available to indicate that it is more desirable to produce waters with a low saturation pH than with a high one.

2. A positive saturation index is invalid if there is not sufficient calcium or alkalinity present to provide a scale-forming film, or if magnesium reduces the pH by precipitation of the hydroxyl ions on heating.

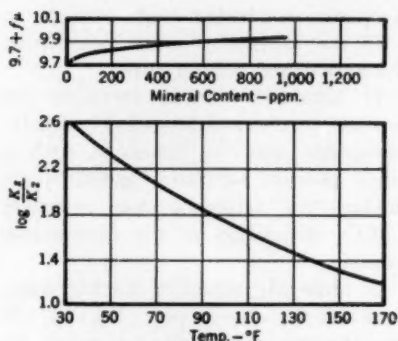


Fig. 5. Constants for Calculation of pH_s Values at Ambient Temperatures

Calcium and alkalinity are expressed as CaCO₃. The pH_s values equal: $(\log K_2/K_1) + (9.7 + f\mu) - \log Ca - \log alk$.

3. Precipitation of magnesium hydroxide may occur within hot-water heaters and the precipitate may be carried into hot-water lines and deposited there.

4. Steps are presented in outline form for choosing the character of water to be produced for maximum stability.

Recommendations

White scale deposits, normally assumed to be calcium carbonate, should be chemically analyzed to establish their composition definitely. Particu-

lar attention to the silica and iron content of eggshell scale may be enlightening.

Conclusion

Data are provided to show that at least 9 of 36 lime-softened waters can be improved by a revised treatment to provide a better balanced water. It behooves the water treatment industry, both in design and in operation, to produce a product that will stand the test of normal uses and not deteriorate to an extent that invites numerous complaints. The production of such water is a more exacting task than might be expected and can be facilitated by proper flexibility in design.

Acknowledgment

The author wishes to express appreciation for the constructive criticism provided by John Dye, Lansing, Mich.; Charles H. Spaulding, Urbana, Ill.; R. G. Gelston, Quincy, Ill.; and John Ryznar, National Aluminate Corp., Chicago, Ill.

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Discussion

By W. R. Gelston

Supt., Water Works Com., Quincy, Ill.

The author is to be congratulated on this fine study of an extremely important matter. In 1942 Charles P. Hoover (1) posed the question: "What is an ideal water for general and municipal use? That is, about what should its alkalinity, its pH, pH_e , calcium, hardness, total solids and silica be?" Langelier replied, "There is no 'ideal' water." F. H. Waring, H. E. Jordan, John Baylis and A. V. Graf all said, "do not know." It is true that many important contributions have since appeared in the literature which pertain to this subject. Most of them are cited in the author's references. It is nevertheless this writer's opinion that there is not enough fundamental information available at present to justify fully an attempt to postulate precise specifications for an ideal lime-softened water. If the author has overextended himself in using this title, it does not detract from the soundness of the paper that follows, since this article is an admirable treatment of calcium carbonate stability insofar as the theory is established today.

Omissions

The paper does not make it clear whether it is possible to produce a soft

water that will be completely satisfactory under all use and exposure conditions. This uncertainty does not stem from the proposed limitations, but from the presence of other factors which may be significant, but upon which no limitations have been placed.

Some of these limitations are suggested but not fully developed. The extent of the distribution system and the length of time the water is exposed to it must be considered. If a slight positive index is maintained, the certainty must be established that a thin eggshell coating will form in all parts of the system, hot and cold, and that there will not be excessive deposition close to the plant and none in the extremities. The reference to a slight positive index is too inexact, and there is no mention whether it is the same at all seasons as the water temperature varies. It is not definite that this ideal coating can protect the unit regardless of the dissolved oxygen content of the water. No indication is given whether top limits exist for the amount of chloride and sulfate ion in the water, to help prevent the formation of strong acids in the pits when hydrogen ions are produced by the anode reaction.

Softening

At a recent symposium on the value of softening, Illinois operators ap-

proached this question from the standpoint that softened water was obviously desirable. This thesis is not necessarily a foregone conclusion. The New England states were blessed from earliest times with a naturally soft water because of the granite rock in that area. The first studies on corrosion were made in that area (2), and even new studies give no evidence that the problem has been satisfactorily solved. Some of the midwestern operators later adopted softening their hard-water supplies, and the practice finally spread to what might be called moderately hard supplies.

It seems impossible to question the desirability of softening a supply that consistently runs over 200 ppm.

It appears unwise to adopt softening before the matter of stability has been completely resolved if 100–200 ppm hardness can be obtained without softening under today's conditions. The principal reasons for advocating softening have been soap saving, better washing conditions and economy in plumbing maintenance. With the wide use of synthetic detergents, the first reasons have lost much of their importance. On the basis of contacts with plumbers and plumbing supply houses, the writer feels safe in asserting that softening a supply of only 150 ppm average hardness is likely to result in substantially greater plumbing maintenance costs for the water consumer. Softening has, however, apparently been somewhat beneficial in preventing water main deterioration.

To improve his own local supply, the writer would suggest, with complete assurance, the abandonment of softening. He does not make this recommendation because there are certainly benefits in softening and its problems, it is felt, should yield to careful experimental work. He also be-

lieves that the matter of water quality and stability is the most important piece of unfinished business confronting the water works industry.

Ramifications of Problem

No matter what one's connection with the water works industry is, the question of softening is of paramount importance. The best type of meter, its expected service life at reasonable accuracy and its maintenance costs are all intimately related to this problem. The materials selected for construction, and even their sizes, should be predicated on the type of water and expected pipe deterioration until this problem is fully solved. The design of treatment plants is very much influenced by the exact quality of water they are expected to produce. All of the above factors, as well as many others, await resolution.

Ordinary tar-coated cast-iron pipe loses about half of its carrying capacity in 40 years in the Quincy, Ill., water system. Two years ago, main cleaning proved to be a very economical method of restoring the lost capacity. Due to the rapid corrosion of this clean iron, resultant red water and the heavy expense of lining the cleaned main, it is difficult to consider the gain in capacity a real improvement.

Approximately a year ago, a rate increase was under negotiation. An industrialist raised just one question—how much new capital expenditure would be needed to have a system that would equal the best in the country? The writer was ashamed to say that he didn't know because of the exact quality characteristics of the most desirable public water supply possible were not known.

That was a sad admission coming from a man trained as a chemist. It

was particularly sad in view of the current availability of all the necessary methods to produce any desired kind of water. Probably no one can refute the statement that if all financial limitations were removed on both plant design and operating cost, the water works industry has the technical knowledge necessary to take any source of water, however undesirable, and condition it to meet any set of detailed specifications. It is the word "detailed" that raises the complications. Everyone is agreed on generalities. The water must be bacteriologically safe, esthetically acceptable, reasonably soft and chemically stable to all materials with which it will come in contact. Just what this water is in terms of its constituents seems impossible to say.

Need for Specifications

The A.W.W.A. has many committees working on standards to apply in purchasing materials. The effect of water quality has a bearing on the work of some of these committees. There is, however, no specification applicable to the water utility's own product with the exception of the U.S. Public Health Service Standards (3). These are a negative sort of standards, merely defining minimum requirements. They are furthermore concerned primarily with potability. This preoccupation is quite proper, but it must be remembered that only a very small proportion of total output is used for drinking.

A detailed specification for an ideal general purpose water supply for a municipality is apparently what is needed. This specification would define a water known to cause none of the difficulties under discussion here. It would then be relatively simple for any management to compare the costs of bringing their supply to this level

with the benefits so derived. This project is certainly worth consideration by the A.W.W.A. on a national level—possibly by its Purification Division. It is certainly as germane to the Association's function as the preparation of specifications for chemicals used in the purification of water.

This specification should not be arbitrarily postulated on purely theoretical considerations. There are two possible approaches. One would be to locate several actual supplies of either naturally soft or artificially softened waters, that do not seem to be causing any of the difficulties mentioned. Carefully controlled experiments should then be made, using and even abusing these waters, to determine whether they actually measure up to the claims made for them. If they do, the characteristics, or possibly an area of characteristics, of an ideal water would be known. The other approach would be to provide a small plant with sufficient flexibility to treat water accurately, varying one characteristic at a time until all possibilities had been tried. The plant output could be used, meanwhile, for a series of controlled experiments designed to bring out the worst characteristics of the water. The latter approach would be rather expensive, but, with organized support by the water industry, the cost might be balanced against the immense financial loss from incrustation and corrosion.

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Author's Closure

The discussion raises a number of very pertinent questions. The author has made no attempt to define any single, specific water composition as being the one and only ideal composition. This is virtually impossible, since it is probable that no two distribution systems are alike in construction and in operation. Certain questions on the retention time within any particular distribution system, or portion of one, are of prime importance. The questions on the extent of active corrosion or active deposition which has taken place are also important.

The data included in the paper would appear to indicate that water for an extensive distribution system of appreciable alkalinity (at least 50 ppm. and preferably 100 ppm.) and a low pH (from 8.2 to 8.5) would be preferable to a water having a lesser alkalinity or a higher pH. It might be assumed that the rate of calcium carbonate deposition would be slower for low pH water since the deposition of the potential excess calcium carbonate would require a two-step reaction of bicarbonate to carbonate, followed by reaction of carbonate with calcium. At the higher pH a greater carbonate ion concentration is present and the reaction of carbonate with calcium can take place more rapidly. This assertion is, of course, in the realm of hypothesis and, like a number of other hypotheses which might be induced from these data, no definite conclusion can be drawn until the facts are applied to practice for the express purpose of determining their applicability.

The author would like again to call attention to the desirability of maintaining a high proportion of alkalinity

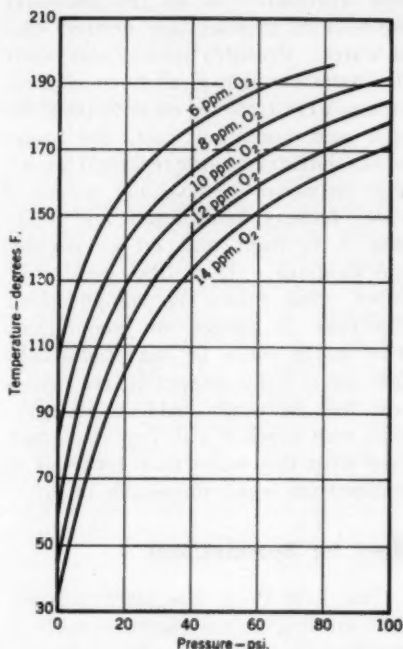
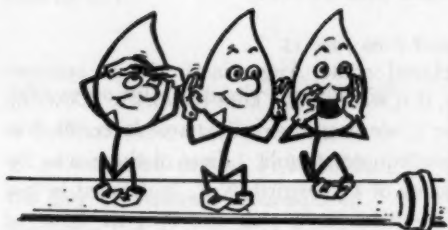


Fig. 6. Maintenance of Oxygen in Solution

The maximum temperature and minimum pressure required to maintain oxygen (from air) in solution are taken from Whipple.

to chloride and sulfate ions in the water in order to reduce the tendency for excessive pitting and tuberculation.

Mr. Gelston's reference to a paper in 1911 by G. C. Whipple was of great interest in view of the information given on the solubility of oxygen at different temperatures and pressures. These data, reproduced in Fig. 6, indicate the maximum temperature at any given pressure which can be tolerated before oxygen gas will be released from the water.



Percolation and Runoff

"Watch the word" is the watchword these days in the field of fluoridation. After all, most of the current fuss about fluorides stems from one unwatched word—"medication." And "medication," or even worse "mass medication," has been plaguing fluoridationists almost ever since it was introduced innocently enough way back when. More than just unwatched, though, or even just unwise or unwanted, "medication" as a description of fluoridation is just plain wrong. In our book, at least, "medication" has always been defined in terms of curing or healing, and to say that fluoridation can either cure or heal dental caries is just plain wistful thinking. Not only the Christian Science leaders who have thrown a monkey wrench into the fluoridation works at San Francisco and Minneapolis, but sundry strictly lay philosophers of fright in various other parts ought to do a little looking up before leaping up to defend against dangers fomented by erroneous terminology.

The way we—and Webster, too, for that matter—look at fluoridation is as "prophylaxis," that is preventive treatment, or part of the "art of guarding against or preventing disease." And if that's "medication," and if "medication" is bad, we'd better call a halt to chlorination quick, if not to such other hydrotherapeutics as filtration, flocculation or even the removal of excess fluorides.

Actually, things aren't as bad as all that, for fuss though there be, fluoridation is spreading so fast that "medication" can't keep up with it. Even New York City last month indicated that it was another of those allegedly "small towns" serious about the subject. As a matter of fact what really is worrying fluoridationists these days is the fluoride shortage that will continue to get worse with each new adoption unless measures to encourage increased production are taken. And there the word, unfortunately, is going to hurt even more, for "increased prices" is the method of encouragement suggested, and that may well mean another inflated nickel per capita per year.

Whatever the word, though, we envy our unborn children the opportunity of keeping cloves out of their mouths.

(Continued on page 2)

(Continued from page 1)

Dowsing dithers have replaced acute Augustiasis as our summer complaint this year. At any rate, if it weren't for Tom Riddick's "Dowsing Is Nonsense" in the July *Harper's*, we might already have succumbed to the summation of some entirely inadequate stimuli. First of these was the evocative epistle of our friend Yaxley of Waterford, N.Y., published in last month's P&R (p. 18). Then we discovered that the August issue of *Pageant* magazine will carry a pro-dowsing discourse and that an early issue of *Harper's* will present a rebuttal to Riddick. Furthermore, in our recent required reading, we stumbled upon not only the story of dowser Willard Wescott of the Canawacta Water Co., Susquehanna, Pa., but this:

DOWSER FINDS WATER AT DISTANCE WITH MAP

Bristol, R.I., June 19 (AP). Water was bubbling from a well on Tower St., today, seeming proof that a Philadelphia man can locate water at a distance with only a map and a dowsing rod.

"I know it sounds crazy," said John Ware, president of the American Water Works Company, Inc., "but it works."

The well is being drilled for the Bristol County Water Company, a subsidiary of Mr. Ware's company. Mr. Ware said he located a spot for the drillers to work by passing a dowsing rod over a map of Bristol spread out on the desk in his office in Philadelphia.

He picked up the art of dowsing with a forked stick from a Pennsylvania Dutchman when he was only sixteen, Mr. Ware said, but the method of locating water at a distance, using a map, was acquired from Henry Gross, a dowser of Biddeford, Me.

Finally, in our most acute attack upon the subject, we dosed ourself with some 300 pages of *The Divining-Rod*, concocted way back in 1926 by Sir William Barrett and Theodore Besterman, yet barely survived this conclusion:

The dowser, in our opinion, is a person endowed with a subconscious supernormal cognitive faculty, which, its nature being unknown, we call after Professor Richet, cryptesthesia. By means of this cryptesthesia, knowledge of whatever object is searched for enters the dowser's subconsciousness and is revealed by means of an unconscious muscular reaction, or less often by an obscure nervous sensation or emotion which produces physiological disturbances, or very rarely by means of direct supernormal cognition made conscious by visualization or hallucination.

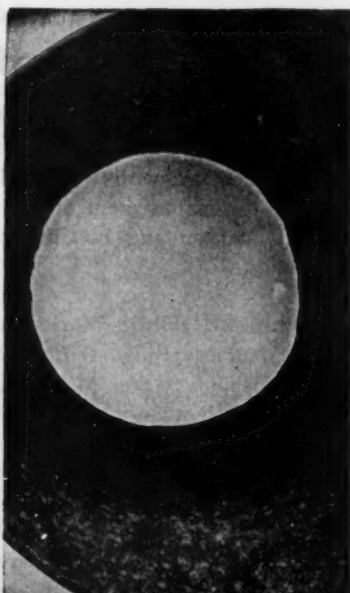
We do not believe that the accumulation of further masses of evidence, though of course this is not undesirable, will make the argument for these contentions any stronger. All that is required is the discovery of some fruitful generalisation which will permit the orthodox scientist to incorporate cryptesthesia into the canon of accepted and indisputable scientific knowledge. We believe that the first movement of thought in this direction will occur from the impossibility of finding any normal explanation of the phenomena of dowsing.

Really timely, then, was the antidither administered by Bill Brush in the July *Water Works Engineering*, when he stuck an editorial scalpel, sharpened by 57 years of water work, into the very mist of cryptesthesia.

(Continued on page 4)

With seven miles of badly corroded 36" and 48" steel pipe up for replacement at an estimated cost of \$1,800,000., the City of Montreal reconditioned the entire line at a total cost of only \$205,000. — a saving of \$1,595,000.

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(Continued from page 2)

The city of Birmingham, Ala., acquired on July 9 the common stock of the Birmingham Water Works Co. and liquidated the company. The utility had been one in the chain controlled by American Water Works Co. As part of the agreement, the city's Water Works Board signed a five-year contract with Municipal Management Co., an affiliate of American, for the management of the system. W. H. H. Putnam remains as general manager and E. Clinton Smith as assistant general manager of the utility.

The 1951 Public Works Congress and Equipment Show to be held at the Memorial Bldg., Detroit, Mich., will feature the following speakers on water supply: Leon A. Smith, superintendent at Madison, Wis.; Wendell R. LaDue, superintendent and chief engineer of the Bureau of Water & Sewerage at Akron, Ohio; and Harry S. Wilson, assistant civil engineer of the Dept. of Water Supply, New York, N.Y.

Tahlman Krumm, partner in the Columbus, Ohio, consulting firm of Burgess & Niple, has been ordered to active duty as a Lieutenant Colonel with the Army General Staff.

(Continued on page 6)

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Here is *another* of the ever-increasing

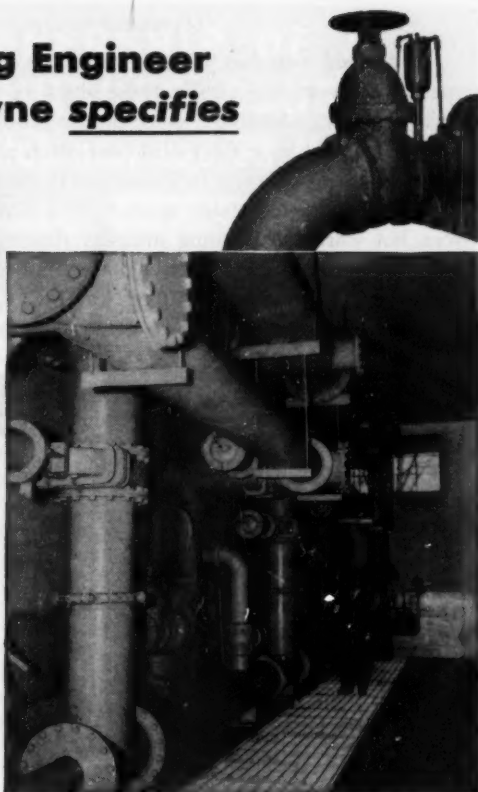
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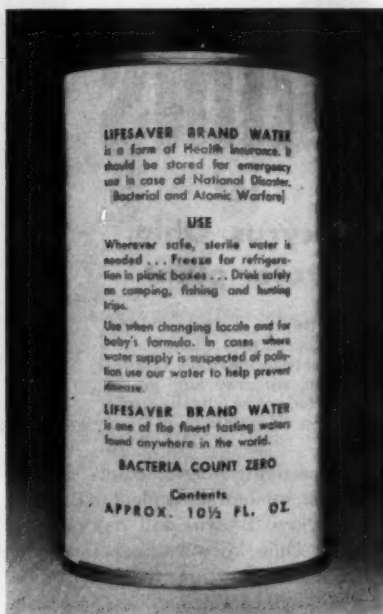
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(Continued from page 4)

Can deed that has the can industry crowing in the best and most expensive advertising media these days is the successful encanment of drinking water. Although work on the problem started way back in 1930 and was brought to a successful conclusion as early as 1941, the new possibilities for canned water in Korea and in the civilian defense program have made it quite bragaboutable again. As a matter of fact, in the interim between hot wars, the canning industry developed some new ideas on merchandising the product that have made it more than just a wartime wonder.

When we heard that canned water was for sale in the regular retail channels, we quick anted up our fifteen cents for the lifesaving 10½-oz. supply



pictured here and ingeniously traced it back to the Multiple Breaker Co. of Boston, which, since 1942, has itself produced "well over ten million cans of sterile, odorless, tasteless, palatable drinking water for the Armed Services, Maritime Commission and Coast Guard." We found, too, that "since 1945 all commercial vessels flying the American flag have carried this drinking water in compliance with the regulations of the Maritime Commission," and, on the other hand, that hunters, fishermen and campers were all considered good customer prospects. And don't be surprised if you soon find it behind your favorite bar. About the only trick that's been missed so far is providing it in concentrated form.

(Continued on page 8)

THE MEMBERSHIP OF A DISTINGUISHED CLUB... C.I.P. Century Club now has 38 Members

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CAST IRON PIPE SERVES FOR CENTURIES

(Continued from page 6)

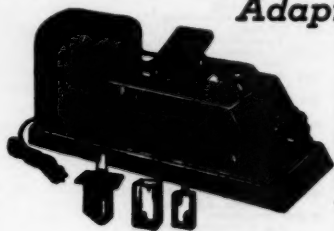
Logic's at work on the water bill and there's no telling where it will stop. It all started, of course, when someone in authority either reasoned or sensed that just as water carried sewage away, the water bill should carry the charge for sewage disposal. That was the beginning of what is now a common practice of joint administration of water and sewer accounts. And now, in Detroit, the logic is being carried one step further, for when the city received permission from the state legislature to purchase garbage disposal units and rent them to home owners, it immediately picked on the water bill as the logical method of collecting rental fees. We haven't figured out yet whether the next step is washing machine rental or just plain laundry bills, but we'll let you know. Meanwhile, the thought of getting along without water usually keeps that bill on top of the pile, whatever its added attractions.

James P. Stewart has been elected president of De Laval Steam Turbine Co. He has been with the firm since 1946 and has been its executive vice president since 1949. Currently he is also president of the Hydraulic Inst., a trade association for the pump manufacturing industry.

(Continued on page 10)

KLETT SUMMERSON ELECTRIC PHOTOMETER

*Adaptable for Use in Water
Analysis*



Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.

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4. A 60" diameter all bronze Venturi nozzle.

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SIMPLEX

VALVE AND METER COMPANY

(Continued from page 8)

Facts unlimited are the regular fare in Professor Don Bloodgood's monthly sanitary engineering news bulletin from the campus of Purdue University. Thus, we have no reason at all to doubt his June lead concerning the candidate for public office who opposed spending \$750,000 for a new water plant, stating publicly: "We do not need a water plant. I can turn on the faucet in my house and get all the water I need." Certainly if it isn't exactly, it is fabulously, true. What we might take issue with him about is his label "Elementary Particles of Water" on a list which included such items as the negative pi meson. To us, that's anything but elementary, my dear Bloodgood.

Fact is, it is high time we paid our respects to the professor for his good offices not only in providing grist for P&R, but in touting A.W.W.A. membership. And while we're feeling grateful to other editors, we want to beam beatifically at John Baylis, who writes *Pure Water*, monthly publication of the Chicago South District Filtration Plant, for this lead paragraph in his May bulletin:

Since 1916, I have missed very few annual conferences of the American Water Works Association. I go, even though I have had to pay my expenses 70 per cent of the time. I cannot afford to miss them; otherwise, I would be rendering less efficient service to my employer. I am a member of other professional societies and try to attend their conventions as frequently as possible. Much valuable information is obtained from all such meetings. For me, I derive most knowledge from the water works conferences because the most talked about subjects pertain to water supply. The trip to Miami, Florida, was expensive; yet I was fully repaid in knowledge gained in addition to a pleasant trip. Those who stayed at home because of the cost missed a good opportunity to learn about the up-to-date improvements in water purification.

All facts, too, and somehow we get a much bigger kick out of finding them in other people's publications.

New Jersey's bill to control the underground storage of natural gas (May P&R, p. 12) has been enacted into law. In its final form, however, the bill does not prohibit such storage but simply requires that a permit be obtained from the state Conservation and Economic Development Dept. Fears that ground water supplies might become polluted by the storage are reported to have been allayed by testimony developed at hearings on the bill.

The Proceedings of the 1950 National Conference on Industrial Hydraulics have been published as a 347-page volume by Illinois Inst. of Technology, Chicago 16, Ill. Copies may be obtained from the National Conference on Industrial Hydraulics, located at the institute, at a cost of \$4.50.

(Continued on page 12)

Choose
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your city a
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of distinction

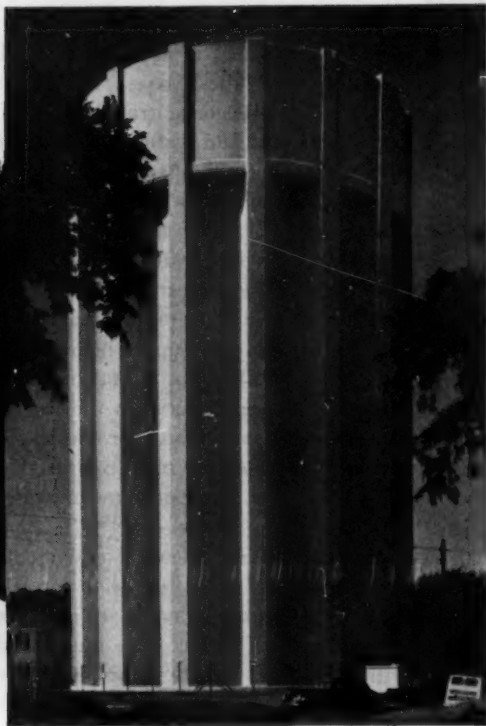


Photo shows 2,000,000 gallon municipal water tank of Topeka, Kansas. T. R. Griest, architect. Roy A. Finney, designer and consulting engineer.

A well-designed water tank such as shown above not only has long-lasting utility but its beauty makes it an outstanding landmark as well. Any city, large or small, can benefit by building such a reinforced concrete water tank. Its durability and enduring beauty make it a structure of which the entire community can be proud.

Reinforced concrete water tanks can be placed in practically any location without marring the skyline or depreciating the value of the property in the area.

Best of all, reinforced concrete water tanks are more economical than other types for they require a minimum of maintenance and last much longer. They give true **low-annual-cost** service, which pleases water works officials, engineers and taxpayers alike.

PORTLAND CEMENT ASSOCIATION

33 W. Grand Ave. } A national organization to improve and extend the uses of portland cement
Chicago 10, Ill. } and concrete through scientific research and engineering field work

(Continued from page 10)

"Just Add Water" is apparently the byword of the food industry from beginning to end these days. In past issues, we've spent a good deal of space describing the concentrated, dried, frozen and prepared foods to which one must "just add water." And though we have always credited water with its much earlier part in food production, we've never seen the formula so clearly defined as in the discussion of the more than a million acres in the Columbia River basin, where "tests have shown the soil will grow nearly anything once water is added."

What brought the subject up was the pushbuttoning last June of the first of a dozen Coulee Dam pumps that will just add water to those acres from the 1,500,000-acre-ft. supply behind the dam. The first unit, which will boost some 720,000 gpm. a total of 280 ft. to supply a total of 85,000 acres, is the largest water pump in the world. But behind its 65,000 hp., of course, is just the same water, providing the first of the nearly 2,000,000 kw. of capacity that the final plant will produce.

Whatever the job, you can count on water.

Harmon E. Keyes, chemical and metallurgical engineer, has joined the technical staff of Infilco Inc. as a special consultant, primarily on the autoxidation process for producing sulfuring acid or iron sulfates from stack gases, a field in which he has done much work. The process is currently in use at the water and sewage plants in Phoenix, Ariz.

F. W. Kittrell, formerly chief of the Stream Sanitation Section for TVA, is now in the Advisory Field Services Branch, Isotopes Div., Atomic Energy Commission, at Oak Ridge, Tenn. He has been placed in charge of the sanitary engineering phases of radioisotope use and disposal and is working on a plan to enlist the cooperation of state health departments in the supervision of this work. Kittrell is the new secretary of the A.W. W.A.'s Water Resources Div., succeeding George Ferguson.

(Continued on page 14)

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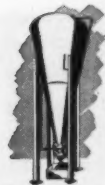
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PERMUTIT

WATER CONDITIONING HEADQUARTERS FOR OVER 38 YEARS



(Continued from page 12)

Here we go again—here being New York, where a new water commissioner by a new mayor is beginning to cry the same old crisis. It's "Water Shortage" again. Having learned at least something from the 1949-50 routine, Commissioner Paduano started early with not only his pleas, prayers and appeals but such stringencies as restricting use of city supplies in street cleaning and lawn sprinkling. Having forgotten just about everything, meanwhile, New Yorkers had begun to wallow in water again, running consumption up to new records almost daily—the highest in June reaching 1,128,000,000 gpd., compared with last year's average of about 900,000,000 and a dependable safe yield of 1,015,000,000.

Broadcasting the alarm again so soon, the city's newspapers might well have raised an editorial eyebrow. If nothing else, at least the Commissioner's choice of a danger signal should have stirred some speculation, for if June-end storage figures are a real measure of impending trouble, we may as well give up now. At any rate, during the past three years, which have seen us go the gamut from poverty to plenty and apparently back again, our storage at that season has varied only 4.1 per cent, between this year's 89.2 per cent and last year's 93.3, dry 1949 ebbing in at 90.7. Even at $2\frac{1}{2}$ billion gallons per percentage point, that would be mighty little margin for error.

But the press has been kind—all too kind, really—in excusing and explaining and expecting the best. Thus one editorial points out that "given a little luck on rainfall, effective public conservation might remove the threat of an emergency by fall" and optimizes that we are two years closer to completion of the Delaware system. Another editor reassures us with the remainder that the 100-mgd. Hudson River reserve is now available. As a matter of fact, everyone is all too kind and too ready to suggest new means of adding to New York City's watershed. One day it was Joseph O'Brien, president of the Water Research Society, who proposed pumping Lake Erie into the present Catskill system through wood-stave pipe. That brought a howl from another willing waterer who called attention to his priority in proposing a similar, "more sensible" pumping of Lake Ontario. Next thing you know it will be the California-Arizona-New York controversy on the Colorado River.

L. B. McKnight, vice president and director of Chain Belt Co., has been elected to the newly created position of executive vice president. His connection with the firm dates from 1927.

Merrill L. Riehl, for the past five years chief chemist at the Ohio Dept. of Health Labs. at Columbus, has become superintendent of water purification for the Mahoning Valley Sanitary Dist. at Youngstown, Ohio.

(Continued on page 16)



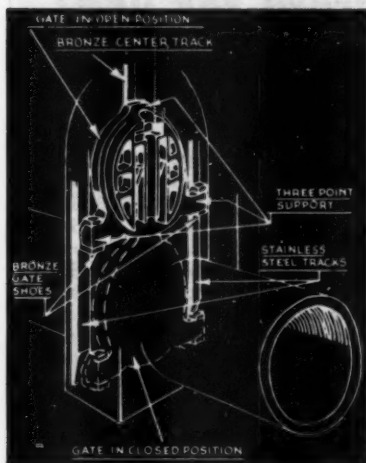
*but not
in a*

VALVE GATE

In an ordinary gate valve, when in a partly open position, flow of water constantly causes the downstream gate to *tilt* into the downstream port opening. That means the gate face gouges the valve seat, causing scarring and leakage.

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Mass., Kansas City, Los Angeles, Memphis, Oklahoma
City, Pittsburgh, San Francisco, Seattle, Waco.

(Continued from page 14)

180,000 board feet of good from last November's ill wind has been offered for sale by the East Orange, N.J., water commission in an effort to salvage something from the 1,200 watershed trees that were victims of the big blow. Meanwhile, the water department is setting out some 7,000 replacements to help hold its water. The smaller they are, . . .

William W. Aultman, water purification engineer for the Metropolitan Water Dist. of Southern California, has accepted the post of assistant director of the Miami, Fla., Dept. of Water & Sewers. He has been connected with the Metropolitan District for over 20 years, and was currently serving as California Section secretary-treasurer. The change in status will become effective on or about September 1.

More than 38 years of service to a water utility were fittingly terminated by an appreciative celebration when Thomas Robertson retired as mechanic of the Glen Ridge, N.J., Water Dept. What started out as an intimate gathering turned out to be a community event as a host of associates, borough officials and plain well-wishers turned out to do "Scotty" honor.

(Continued on page 18)

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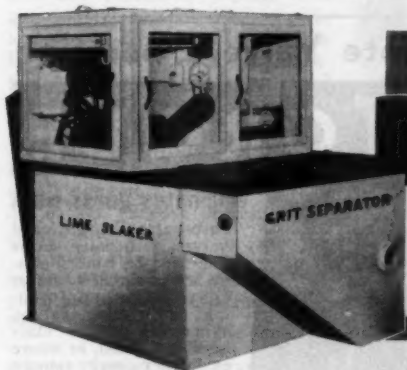
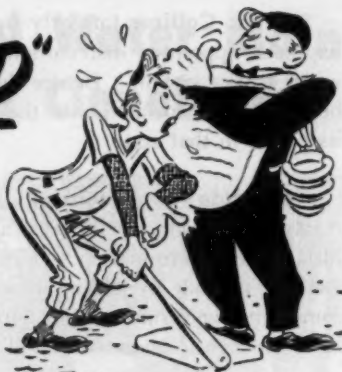
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Chemical Elevators



OMEGA
The Last Word in Feeders



(Continued from page 16)

T. H. Collins, formerly manager of the Ozark, Ala., water works, has been appointed distribution superintendent of the Birmingham, Ala., water works system. Before the Ozark works were acquired by the city, he had been associated with the Alabama Water Service Co. at several of its plants in that state.

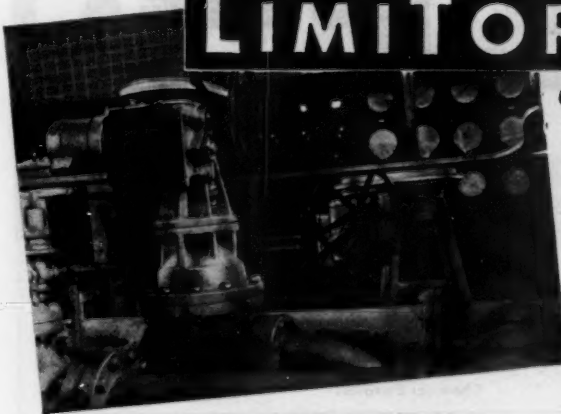
Fluoride dosage control is said to be aided by use of the Taylor Water Analyzer, a product of W. A. Taylor & Co., 7300 York Road, Baltimore 4, Md. The determination, which utilizes a modification of the La Mar method, is made by adding a single reagent to the water to be tested and comparing the resultant color with a set of liquid standards. The standards are permanently mounted in a plastic slide and are warranted not to fade.

The formation of Dresser Equipment Co. as an operating subsidiary of Dresser Industries, Inc., has been achieved by the consolidation of Kobe, Inc., and International Derrick & Equipment Co.—both Dresser subsidiaries. They will now function as the Kobe and Ideco divisions, respectively, of Dresser Equipment Co.

(Continued on page 72)

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4 Miles of Steel Water Main Installed in Cleveland

This photograph was taken recently during construction of Section 1 of the Division-Almira Water Main, originating at the Division Avenue Pumping Station in Cleveland. The new main consists of approximately 23,000 ft of 48 in. and 36 in. Bethlehem Tar-Enameled Water Pipe. Nearly 250 girth seams in the line were field-welded; other joints were made with mechanical couplings. The Kalill Company, Cleveland, was the contractor.

Bethlehem Tar-Enameled Water Pipe is ideal pipe for water-main service because of its durability and economy. It can be installed conveniently in any type of terrain. The pipe is resistant to incrustation and corrosion because it is generously coated, both inside and out, with a smooth, uniform layer of coal-tar enamel. Leak-proof girth seams can be obtained by welding or riveting, or with mechanical couplings.

Bethlehem Tar-Enameled Water Pipe is made in 40-ft lengths, and in all diameters from 22 in. i.d. up to the largest permitted by common carriers.

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WATER PIPE



The Reading Meter

Water Supply and Treatment. Charles P. Hoover. *National Lime Assn., 925—15th St., N.W., Washington 5, D.C. (7th ed., 1951) \$1.25 plus 12¢ postage*

This new version of an old standby was revised by C. P. Hoover shortly before his death. It is published within cloth covers for the first time, thus increasing its durability. New material has been added on lime sludge disposal and reclamation, total hardness determination, ion exchange and recarbonation of softened waters. Since the first edition appeared in 1934, approximately 50,000 copies of the book have been distributed.



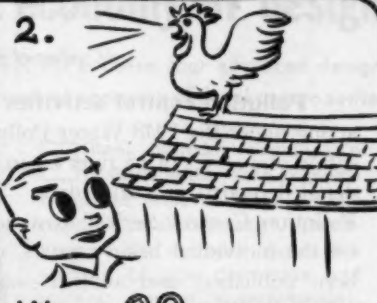




Building Code Requirements for Reinforced Concrete—ACI 318-51. *American Concrete Inst., 18263 W. McNichols Rd., Detroit 19, Mich. (1951) 50¢*

This document, intended to be incorporated in or adopted by reference in a general building code, is a revision of a previous standard for the design and construction of reinforced concrete buildings. A significant change is to eliminate the necessity for anchoring hooks for new-type deformed reinforcing bars under certain circumstances, thus permitting substantial steel savings. Plain bars must still be hooked under the code.

Advanced Fluid Dynamics and Fluid Machinery. R. C. Binder. *Prentice-Hall, Inc., New York (1951) \$8*

Intended for the specialist, this volume is considered an extension of beginning studies on fluid flow, and is designed as a preliminary step toward more advanced studies. The book is divided into three parts, of which the first deals with one-dimensional compressible flow, flow with friction and heat transfer, and boundary layer flow. Part II is a discussion of fluid machinery, such as pumps and turbines. Part III reverts to the part I discussion of fluid dynamics, but on a more complex level.

(Continued on page 22)

<p>1.</p>  <p>WHAT  WENT WESTWARD?</p>	<p>2.</p>  <p>WHAT  ARE ALARM CLOCKS ON FARMS?</p>
<p>3.</p>  <p>WHAT  SAILED THE SEVEN SEAS?</p>	<p>4. WHERE CAN YOU GET RELIABLE EQUIPMENT FOR FLUORIDATION?</p>  <p>ANSWER: %PROPORTION %</p>

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The Reading Meter

(Continued from page 20)

Pollution control activities of the U.S. Public Health Service, acting under the 1948 Water Pollution Control Act, include the publication of a series of 15 river basin summary reports, to be followed by detailed reports at a later date. The first publication in this "Water Pollution Control Series" is a national summary of pollution data. Of the individual basin reports, one—on the Tennessee River—has been published, and another—on the Missouri—is in press. The others are scheduled to appear within the next few months. Other publications of U.S.P.H.S. which deal with pollution are:

Water Pollution in the United States. No. 1 in Water Pollution Series. This is a 44-page, nontechnical report generally presenting the background of the pollution problem, its analysis, and the cost of and responsibility for its solution.

Tennessee River Drainage Basin. No. 2 in Water Pollution Series. This is a 121-page treatment of both the entire basin and the eight subbasins.

Clean Water Is Everybody's Business. Public Health Service Pub. 11. A nontechnical, 26-page booklet, this publication is intended to stimulate antipollutional interest and action by individuals and civic groups.

Suggested State Water Pollution Control Act and Explanatory Statement. Public Health Service Pub. 49. An exposition and text of a proposed act for the states is presented, in accordance with Congressional direction, in order to encourage enactment of uniform state laws.

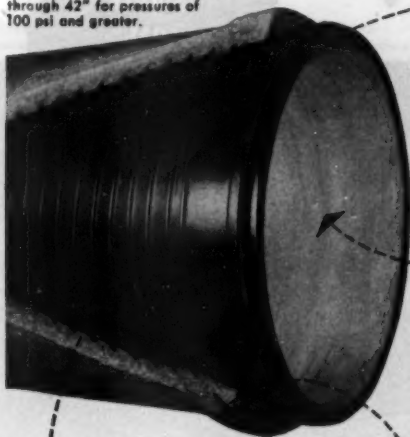
Water Pollution Control. Excerpts from *A Water Policy for the American People*. Public Health Service Pub. 58. Various portions of Vol. I of the President's Water Resources Policy Commission report have been reprinted in this booklet. The material reprinted, all of which bears on the pollution problem, includes Chapter 12, "Domestic and Industrial Water Supply"; Chapter 13, "Pollution Control"; and excerpts from other sections.

Copies of these publications may be obtained from the Div. of Water Pollution Control, Public Health Service, Federal Security Agency, Washington 25, D.C.

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3 Steel reinforcing rods, which supplement the required steel area*, are wrapped under measured tension and accurate spacing around the concrete lined cylinder. The section modulus is thus increased while the concrete lining is placed under slight initial compression. The result is, in effect, a modified prestressed design.

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<p>BURGESS & NIPLE <i>Consulting Engineers</i> (Established 1908)</p> <p>Water supply, treatment and distribution Sewage and industrial wastes disposal Investigations, reports, appraisals, rates Airports Municipal Engineering Supervision</p> <p>584 E. Broad St. Columbus 15, Ohio</p>	<p>DE LEUW, CATHER & COMPANY</p> <p>Water Supply Sewerage Railroads Highways</p> <p>Grade Separations—Bridges—Subways Local Transportation</p> <p>Investigations—Reports—Appraisals Plans and Supervision of Construction</p> <p>150 N. Wacker Drive Chicago 6 79 McAllister St. San Francisco 2</p>
<p>BURNS & McDONNELL <i>Consulting and Designing Engineers</i></p> <p>Water Works, Light and Power, Sewerage, Reports, Designs, Appraisals, Rate Investigations.</p> <p>Kansas City 2, Mo. Cleveland 14, Ohio P.O. Box 7088 1404 E. 9th St.</p>	<p>NORMAN O. ELDRED <i>Consulting Engineer</i></p> <p>Water Works, Softening and Filtration Plants. Municipal and Industrial Water Conditioning Equipment of All Types. Designs, Plans, Specifications, Estimates, Reports, Supervision.</p> <p>508 Draper St. Vicksburg, Mich. Vicksburg 3271</p>
<p>JAMES M. CAIRD Established 1898 C. E. CLIFTON, H. A. BENNETT <i>Chemist and Bacteriologist</i></p> <p>WATER ANALYSIS TESTS OF FILTER PLANTS</p> <p>Cannon Bldg. Troy, N. Y.</p>	<p>FAY, SPOFFORD & THORNDIKE <i>Engineers</i></p> <p>Charles E. Spofford Ralph W. Horne John Ayer William L. Hyland Bion A. Bowman Frank L. Lincoln Carroll A. Farwell Howard J. Williams</p> <p>WATER SUPPLY AND DISTRIBUTION—DRAINAGE SEWERAGE AND SEWAGE TREATMENT—AIRPORTS</p> <p>Investigations Reports Designs Valuations Supervision of Construction</p> <p>Boston New York</p>
<p>CAMP, DRESSER & McKEE <i>Consulting Engineers</i></p> <p>Water Works, Water Treatment, Sewerage and Wastes Disposal, Flood Control</p> <p>Investigations, Reports, Design Supervision, Research, Development</p> <p>6 Beacon St. Boston 8, Mass.</p>	<p>FINKBEINER, PETTIS & STROUT CARLETON S. FINKBEINER C. E. PETTIS HAROLD K. STROUT <i>Consulting Engineers</i></p> <p>Reports, Designs, Supervision, Water Supply, Water Treatment, Sewerage, Sewage Treatment, Wastes Treatment, Valuations & Appraisals</p> <p>518 Jefferson Avenue Toledo 4, Ohio</p>
<p>THE CHESTER ENGINEERS</p> <p>Water Supply and Purification, Sewerage Systems, Sewage and Industrial Waste Treatment, Power Development and Applications, Investigations and Reports, Valuations and Rates</p> <p>210 E. Park Way at Sandusky PITTSBURGH 12, PA.</p>	<p>FREESE, NICHOLS AND TURNER <i>Consulting Engineers</i></p> <p>2111 National Standard Building Houston 2, Texas CH-1624</p>
<p>CONSOER, TOWNSEND & ASSOCIATES</p> <p>Water Supply—Sewerage Flood Control & Drainage—Bridges Ornamental Street Lighting—Paving Light & Power Plants—Appraisals</p> <p>351 E. Ohio St. Chicago 11</p>	<p>FULBRIGHT LABORATORIES, Inc. <i>Consultants</i> <i>Chemists and Chemical Engineers</i></p> <p>Industrial Water and Waste Surveys</p> <p>Tel. 5-5726 Box 1284 Charlotte, N. C.</p>

<p>GANNETT FLEMING CORDDRY & CARPENTER, Inc. <i>Engineers</i> Water Works—Sewerage Industrial Wastes—Garbage Disposal Roads—Airports—Bridges—Flood Control Town Planning—Appraisals Investigations & Reports Harrisburg, Pa. Scranton, Pa. Pittsburgh, Pa.</p>	<p><i>Professional Services</i> (contd.)</p>
<p>G. L. GEISINGER <i>Consulting Engineer</i> Water Works—Treatment—Filtration Design—Operation—Reports Laboratory Analysis 122 Elliott Ave., W. Seattle 99, Wash.</p>	<p>CHARLES HAYDOCK <i>Consulting Engineer</i> Water Works and Sanitation Industrial Wastes Design, Construction, Operation and Management Reports and Valuations 2314 Girard Trust Co. Bldg. Broad St. & S. Penn Square Philadelphia 2</p>
<p>GILBERT ASSOCIATES, INC. <i>Engineers and Consultants</i> Water Supply and Purification Sewage and Industrial Waste Treatment Chemical Laboratory Service Investigations and Reports New York Reading, Pa. Washington Houston Philadelphia</p>	<p>RICHARD HAZEN <i>Consulting Engineer</i> Municipal and Industrial Water Supply and Treatment Sewage and Waste Disposal Reports, Design, Construction Operations 110 East 42nd Street New York 17, N.Y.</p>
<p>GLACE & GLACE <i>Consulting Sanitary Engineers</i> Sewerage and Sewage Treatment Water Supply and Purification Industrial Wastes Disposal Design, Construction, and Supervision of Operation 1001 North Front St., Harrisburg, Pa.</p>	<p>HORNER & SHIFRIN <i>Consulting Engineers</i> W. W. Horner S. W. Jens H. Shifrin E. E. Bloss V. C. Lischer Water Supply—Airports—Hydraulic Engineer- ing—Sewerage—Sewage Treatment—Municipal Engineering—Reports Shell Building St. Louis 3, Mo.</p>
<p>GREELEY & HANSEN <i>Engineers</i> Water Supply, Water Purification Sewerage, Sewage Treatment Flood Control, Drainage, Refuse Disposal 220 S. State Street, Chicago 4</p>	<p>ROBERT W. HUNT CO. <i>Inspection Engineers</i> (Established 1888) Inspection and Test at Point of Origin of Pumps, Tanks, Conduit, Pipe and Accessories 173 W. Jackson Blvd. Chicago 4, Ill. and Principal Mfg. Centers</p>
<p>HAVENS & EMERSON W. L. HAVENS C. A. EMERSON A. A. BURGER F. C. TOLLES F. W. JONES <i>Consulting Engineers</i> Water, Sewage, Garbage, Industrial Wastes, Valuations—Laboratories Leader Bldg. Woolworth Bldg. CLEVELAND 14 NEW YORK 7</p>	<p>THE JENNINGS-LAWRENCE CO. C. C. Walker F. L. Swickard B. I. Sheridan R. L. Lawrence Civil & Municipal Engineers Consultants Water Supply, Treatment & Distribution Sewers & Sewage Treatment Reports—Design—Construction 12 N. Third Street Columbus 15, Ohio</p>

<p>JONES, HENRY & SCHOONMAKER (Formerly Jones & Henry) <i>Consulting Sanitary Engineers</i></p> <p>Water Works Sewerage & Treatment Waste Disposal</p> <p>Security Bldg. Toledo 4, Ohio</p>	<p>Parsons, Brinckerhoff, Hall & Macdonald G. Gale Dixon, Associate <i>Engineers</i></p> <p>Dams Water Works Sewerage Airports Bridges Tunnels Traffic & Transportation Reports Highways Subways Foundations Valuations Harbor Works Industrial Buildings Power Developments</p> <p>31 Broadway, New York 6, N.Y.</p>
<p>MORRIS KNOWLES, INC. <i>Engineers</i></p> <p>Water Supply and Purification, Sewerage and Sewage Disposal, Industrial Wastes, Valuations, Laboratory, City Planning.</p> <p>Park Building Pittsburgh 22, Pa.</p>	<p>MALCOLM PIRNIE ENGINEERS <i>Civil & Sanitary Engineers</i></p> <p>MALCOLM PIRNIE ERNEST W. WHITLOCK G. G. WERNER, JR.</p> <p>Investigations, Reports, Plans Supervision of Construction and Operations Appraisals and Rates</p> <p>25 W. 43rd St. New York 18, N. Y.</p>
<p>R. M. LEGGETTE <i>Consulting Ground Water Geologist</i></p> <p>Water Supply Salt Water Problems Dewatering Investigations Recharging Reports</p> <p>351 Fifth Avenue New York 17, N. Y.</p>	<p>THE PITOMETER COMPANY <i>Engineers</i></p> <p>Water Waste Surveys Trunk Main Surveys Water Distribution Studies Water Measurement & Special Hydraulic Investigations</p> <p>50 Church Street New York</p>
<p>Roberto Meneses Hoyos & Co. <i>Ground Water Engineers</i></p> <p>Water Supply Geophysics Test Drilling Flow Tests Explorations Reports Design, Valuations & Supervision</p> <p>Reforma 12 Mexico City</p>	<p>LEE T. PURCELL <i>Consulting Engineer</i></p> <p>Water Supply & Purification; Sewerage & Sewage Disposal; Industrial Wastes; Investigations & Reports; Design; Supervision of Construction & Operation Analytical Laboratories</p> <p>1 Lee Place Paterson 1, N. J.</p>
<p>METCALF & EDDY <i>Engineers</i></p> <p>Water, Sewage, Drainage, Refuse and Industrial Wastes Problems Airfields Valuations Laboratory</p> <p>Statler Building Boston 16</p>	<p>THOMAS M. RIDDICK <i>Consulting Engineer and Chemist</i></p> <p>Municipal and Industrial Water Purification, Sewage Treatment, Plant Supervision, Industrial Waste Treatment, Laboratories for Chemical and Bacteriological Analyses</p> <p>369 E. 149th St. New York 55, N.Y.</p>
<p>THE H. C. NUTTING COMPANY <i>Engineers</i></p> <p>Water Distribution Studies Water Waste Surveys Trunk Main Surveys Meter and Fire Flow Test</p> <p>4120 Airport Road Cincinnati 26, Ohio</p>	<p>RIPPLE & HOWE <i>Consulting Engineers</i></p> <p>O. J. RIPPLE B. V. HOWE Appraisals—Reports Design—Supervision Water Works Systems, Filtration and Softening Plants, Reservoirs, and Dams, Sanitary and Storm Sewers, Sewage Treatment Plants, Refuse Disposal, Airports</p> <p>426 Cooper Bldg., Denver 2, Colo.</p>

<p>NICHOLAS A. ROSE <i>Consulting Ground Water Geologist</i> Investigations Reports Advisory Service 1309 Anita Ave. Houston 4, Tex.</p>	<p><i>Professional Services</i> (contd.)</p>
<p>RUSSELL & AXON <i>Consulting Engineers</i> GEO. S. RUSSELL F. E. WENGER JOE WILLIAMSON, JR. Water Works, Sewerage, Sewage Disposal, Industrial and Power Plants, Appraisals 408 Olive St. Municipal Airport St. Louis 2, Mo. Daytona Beach, Fla.</p>	<p>ALDEN E. STILSON & ASSOCIATES <i>Limited</i> <i>Consulting Engineers</i> Water Supply Sewerage Waste Disposal Mechanical Structural Surveys Reports Appraisals 209 South High St. Columbus, Ohio</p>
<p>SAMUEL SHENKER <i>Chemical Consultant</i> Water Treatment Laboratory Service — 155 S. Broadleigh Rd., Columbus 9, Ohio</p>	<p>WESTON & SAMPSON <i>Consulting Engineers</i> Water Supply and Purification; Sewerage, Sewage and Industrial Waste Treatment. Reports, Designs, Supervision of Construc- tion and Operation; Valuations. Chemical and Bacteriological Analyses 14 Beacon Street Boston 8, Mass.</p>
<p>J. E. SIRRINE COMPANY <i>Engineers</i> Water Supply & Purification, Sewage & Industrial Waste Disposal, Stream Pollution Reports, Utilities, Analyses Greenville South Carolina</p>	<p>WALTER N. WHITE & WILLIAM F. GUYTON <i>Consulting Ground-Water Hydrologists</i> GROUND-WATER SUPPLIES Evaluation; Planning of New Developments; Operational and Maintenance Advice; Legal Proceedings; Artificial Recharge, Induced River Infiltration, Well Interference and Other Ground-Water Problems. 307 W. 12th St. 10 Mississippi Ave. Austin 1, Texas Silver Spring, Md.</p>
<p>SMITH AND GILLESPIE <i>Consulting Engineers</i> Water Supply and Treatment Plants; Sewerage, Sewage Treatment; Utilities; Zoning; Reports, Designs, Supervision of Construction and Operation; Appraisals. P.O. Box 1048 Jacksonville, Fla.</p>	<p>WHITMAN & HOWARD <i>Engineers</i> (Est. 1869.) Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems 89 Broad St. Boston, Mass.</p>
<p>STANLEY ENGINEERING COMPANY — Waterworks—Sewerage Drainage—Flood Control Airports—Electric Power — Hershey Building Muscatine, Ia.</p>	<p>WHITMAN, REQUARDT & ASSOCIATES <i>Engineers Consultants</i> Civil—Sanitary—Structural Mechanical—Electrical Reports, Plans, Supervision, Appraisals 1304 St. Paul St. Baltimore 2, Md.</p>

Membership Changes



NEW MEMBERS

Applications received June 1 to June 30, 1951

Arrowhead Lime & Chemical Co., H. R. Brookman, Vice-Pres., 1840 E. 25th St., Los Angeles 58, Calif. (Assoc. M. July '51)

Banik, John A., Field Service Engr., Flox Co., 119 Park Ave., Grand Forks, N.D. (Apr. '51) *P*

Barbieri, Vincenzo, Chief San. Engr., High Commissariat for Hygiene & Public Health, Palazzo Viminape, Rome, Italy (July '51) *MP*

Barning, Carl Phillip, Jr., Chemist, Water Works Dept., Evansville, Ind. (July '51) *P*

Brookman, H. R., *see* Arrowhead Lime & Chemical Co.

Burris, Michael M., Cons. Engr., 485 Engle St., Englewood, N.J. (July '51) *MPR*

Carey, James W., Cons. Engr., Carey & Kramer, 1917—1st Ave., Seattle 1, Wash. (July '51) *MPR*

Carlson, Ernest C., Supt., Water Dept., Berkley, Mich. (July '51) *MP*

Carter, J. Gordon, Asst. Supt., Water Dept., 106 W. Lake St., Petoskey, Mich. (July '51) *P*

Casler, Vernon C., Supervisor of Public Works, Borough of Seaside Heights, Seaside Heights, N.J. (July '51)

Cave, Reginald John, Cons. Engr., 1553 Robson St., Vancouver, B.C. (Apr. '51)

Chisholm, William Orville, Engr., James F. MacLaren Assocs., 705 Yonge St., Toronto 5, Ont. (July '51)

Crawford, Ronald, *see* Mountain Lakes (N.J.)

Di Franco, Salvatore, Utility Chief Engr., Socony Vacuum Italiana, Naples, Italy (Jan. '51) *MPR*

Duszynski, Edwin J., Mgr., Water Utility, 3555 E. Pabst Ave., Cudahy, Wis. (July '51) *MP*

Ehly, Charles George, Water Purif. Foreman, E. I. Du Pont de Nemours & Co., Inc., Box 1477, Richmond, Va. (July '51) *MP*

Eldson, Clarence S., Engr. & Director, Water & Sewer Dept., City Hall, Waycross, Ga. (July '51)

Foley, Frank C., Head, Ground Water Div., State Geological Survey, Urbana, Ill. (July '51) *R*

Hardon, Dale W., Master Mechanic, Central Fibre Products Co., Tama, Iowa (July '51)

Hill, R. Travis, Bacteriologist, State Dept. of Health Lab., Box 1877, Richmond 19, Va. (July '51) *P*

Holt, Robert B., *see* Springfield (Ohio) Water Div.

Horn, Paul, Mgr., Water Works Utility, Bourbon, Ind. (July '51)

Huffschtmidt, E. G., *see* Industrial Iron Works

Humphreys, Lowell K., City Engr., City Hall, Hiawatha, Kan. (July '51) *MPR*

Industrial Iron Works, E. G. Huffschtmidt, Partner, 6011 S. W. Macadam, Portland 1, Ore. (Assoc. M. July '51)

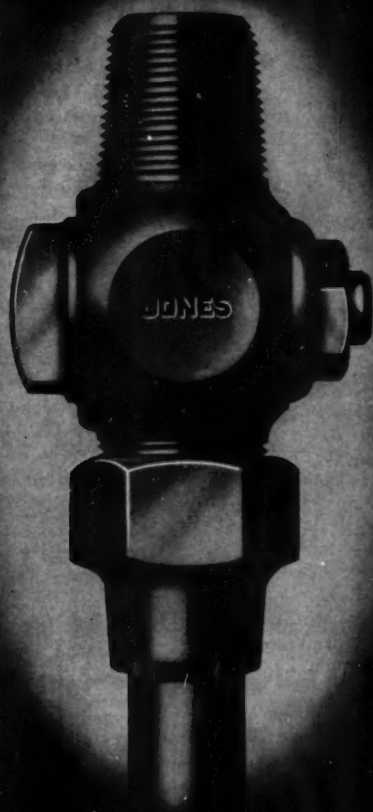
Jennings, Richard T., Asst. Hydraulic Engr., Water Bureau, State Public Service Com., 233 Broadway, New York 7, N.Y. (July '51)

Johnston, Donald P., Secy.-Mgr., Carlsbad Mutual Water Co., Box 7, Carlsbad, Calif. (July '51) *M*

Jones, William A., Water & Gas Distr. System, Box 787, Marfa, Tex. (July '51) *MPR*

Kuykendall, Robert P., Sales Engr., Inflico Inc., 802 Kennedy Bldg., Tulsa, Okla. (July '51)

(Continued on page 32)



JONES

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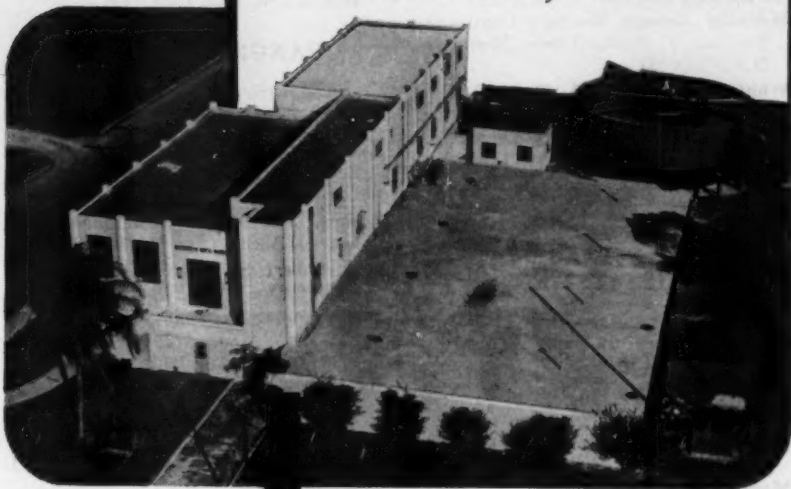
(Continued from page 30)

- Lavery, Gordon Laurence, Jr.**, San. Engr., East Bay Munic. Utility Dist., Box 720, Oakland, Calif. (July '51) *MP*
- Macfarlan, Donald, Jr.**, Dist. Sales Mgr., Pennsylvania Salt Mfg. Co., 1114 Buhl Bldg., 535 Griswold St., Detroit 26, Mich. (July '51)
- MacLaren, James W.**, Engr., James F. MacLaren Assocs., 705 Yonge St., Toronto, Ont. (July '51)
- Maclean, Donald G.**, Engr., James F. MacLaren Assocs., 705 Yonge St., Toronto, Ont. (July '51)
- Martin, R. Roger**, Gibbs & Hill, Inc., 11 W. 42nd St., New York 18, N.Y. (Jan. '51) *MPR*
- Mc Duffe, Peter P.**, Waterworks Supt., 108—26th St., N., Brandon, Man. (Apr. '51)
- McGinnis, Robert M.**, Waterford Township Engr., 4995 W. Huron St., Pontiac, Mich. (July '51) *MPR*
- Metallizing Engineering Co., Inc.**, Vernon R. Smith, Mgr., Sales Promotion Dept., 38-14—30th St., Long Island City 1, N.Y. (Assoc. M. July '51)
- Mitchell, Ward**, Water Plant Operator, Marine Corps Recruit Depot, Parris Island, S.C. (Apr. '51) *P*
- Mountain Lakes, Borough of**, Ronald Crawford, Engr. & Supt., Water Dept., 160 Boulevard, Mountain Lakes, N.J. (Corp. M. July '51)
- Nicholson, Robert M.**, Village Engr., 1560 Lakeshore Rd., Long Branch, Ont. (July '51)
- O'Connor, Leo**, see O'Connor Rust-Proofing Co.
- O'Connor Rust-Proofing Co.**, Leo O'Connor, Vice-Pres., 13810 S. Vermont Ave., Los Angeles 44, Calif. (Assoc. M. July '51)
- Palmer, Kenneth C.**, Supt. of Water Dept., Bolton Landing, N.Y. (Apr. '51) *MPR*
- Paul, Kendall Saxman**, Water Works Operator, San Luis Rey Heights Mutual Water Co., Star Route 1, Box 50, Fallbrook, Calif. (July '51) *M*
- Perkins, Gertrude, (Miss)**, Acting Mgr., Waveland Water Co., Box 125, Waveland, Miss. (Apr. '51) *M*
- Petty, Harold N.**, Chief Supervisor, Utilities, General Electric Co., Richland, Wash. (July '51) *MPR*
- Pickett, John M.**, San. Engr., Post Engr., Camp Polk, La. (July '51) *MR*
- Poole, George M.**, Bacteriologist, Water Works, Evansville, Ind. (July '51) *MP*
- Powell, Hugh B.**, Mayor, Keysville, Va. (July '51) *M*
- Powell, Leon**, Water Plant Operator, State Hospital, Spencer, W. VA. (July '51) *MP*
- Price, Jacques**, Cons. Civ. Engr., Box 340, Windsor, N.S. (July '51)
- Priess, LeRoy**, Supt., Utilities, Stafford, Kan. (July '51) *MPR*
- Ratcliffe, Donald K.**, Salesman, Gen. Chem. Div., Allied Chemical & Dye Corp., Box 970, Charlotte, N.C. (July '51) *P*
- Rateuke, John H.**, Water Supt., Washington, Kan. (July '51) *MP*
- Rudolph, John H.**, Secy., Concrete Supply Co., Inc., 2020 W. Iowa St., Evansville, Ind. (July '51)
- Sanchez, Herman**, Water Supt., Bernalillo, N.M. (July '51) *MPR*
- Simmons, L. R.**, Supt., Water Works, Grand Saline, Tex. (July '51)
- Smith, Vernon R.**, see Metallizing Engineering Co., Inc.
- Smith, W. R.**, Supt., Water Production, Box 1213, Duncan, Okla. (July '51)
- Spencer, Jay Warren, Jr.**, Sales Engr., Water Meter Div., Rockwell Mfg. Co., 1000 Madison St., Denver, Colo. (July '51) *M*
- Spielman, Harry G.**, Asst. Treas., C. W. Lauman & Co., Inc., Box 76, Bethpage, N.Y. (July '51) *R*
- Springfield Water Div.**, Robert B. Holt, Supt., 115 S. Fountain Ave., Springfield, Ohio (Mun. Sv. Sub. July '51)
- Stauff, John Henry, Jr.**, San. Engr., Headman, Ferguson & Carollo, 5915 Hollis St., Emeryville 8, Calif. (July '51) *MP*
- Stotsenberg, Edward George**, Partner, Blight & Wheeler, 6331 Hollywood Blvd., Los Angeles 28, Calif. (July '51) *MPR*
- Ueltzen, Max E.**, Mgr., Board of Public Works, Kennett, Mo., (Apr. '51) *MPR*
- Wade, Wayne D.**, Process Engr., Skelly Oil Co., Box 1121, El Dorado, Kan. (July '51) *MP*

(Continued on page 34)

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(Continued from page 32)

Wagner, Robert F., Branch Mgr., Thompson Hayward Chem. Co., Box 413, North Little Rock, Ark. (Apr. '51) *P*

Wardrop, William R., Field Repr., Metal-Cladding, Inc., 128 Lakeview Ave., Buffalo 1, N.Y. (July '51) *MP*

Webb, Lester Charles, Jr., Field Repr., Inflico Inc., 35 W. Columbia, Orlando, Fla. (July '51) *MP*

Wechsler, George, Wechsler Contracting Co., Inc., 11 Bushnell Ave., Monticello, N.Y. (July '51) *P*

Whitford, Robert Earl, Tech. Advisor, Utility Purchases, Reynolds Metals Co., Reynolds Metals Bldg., Richmond 19, Va. (July '51) *M*

Williams, J. S., Director of Public Works & Utilities, Box 813, Bay City, Tex. (July '51) *M*

REINSTATEMENTS

Crabbe, Ben F., Mgrs. Repr., Box 3413, Orlando, Fla. (July '35)

Gibson, William R., Northwest Filter Co., 122 Elliott Ave., W., Seattle 99, Wash. (Jan. '38) *P*

Laberteaux, Kenneth P., City Engr., Hastings, Mich. (Apr. '44) *M*

Marshall, W. W., Water Works Supt., Orangeville, Ont. (Jan. '44)

Pegg, J. F., Supt., Water Works Dept., Public Utilities Com., Blenheim, Ont. (Jan. '48) *M*

Waller, Edward G., Pres., E. G. Waller & Assoc., 604 Main St., Dauphin, Man. (Jan. '46)

LOSSES

Resignations

Burlington Mills Corp., R. A. Gilliam, Div. Mgr., N. Eugene St., Greensboro, N.C. (Corp. M. Apr. '48)

Byerley, E. F., Local Mgr., Arkansas Utilities Co., 121 N. 1st St., West Helena, Ark. (Apr. '45) *M*

Campbell, E. W., Director, Div. of San. Eng., State Dept. of Health & Welfare, Augusta, Me. (Dec. '23) *P*

Fuerness, William, Member, Water Board, 88 Dunning Ave., Webster, N.Y. (Jan. '50) *M*

Gilliam, R. A., see Burlington Mills Corp.

Kerr, Harry, Supt., Water Works, New Philadelphia, Ohio (Oct. '46)

Rian, John, Supt. of Gas & Water Operations, Northern Indiana Public Service Co., 500 Broadway, Gary, Ind. (Oct. '50)

Young, B. C., 501 E. Carpenter St., Hutchinson, Kan. (Apr. '49)

CHANGES IN ADDRESS

Changes received between June 5 and July 5, 1951

Acevedo-Quintana, F., Cons. San. Engr., Edificio Araure 202, Calle Real-Sabana Grande, Caracas, Venezuela (Jan. '41)

Adams, John M., c/o Baranof Hotel, Juneau, Alaska (Apr. '40) *MP*

Arp, Robert S., 1146 W. 12th Ave., Albany, Ore. (Apr. '50)

Bailey, Pierces, Jr., Engr., Div. of Water, Bureau of Eng., 3725 Kershaw Ave., Toledo, Ohio (Apr. '50) *M*

Baker, City of, C. S. Vergeer, City Mgr., City Hall, Baker, Ore. (Corp. M. Jan. '39) *MPR*

Barton, Harry, Box 1, Livingston, N.J. (Dec. '28)

Baugall, V. A., see Junction City (Kan.) Water Dept.

Blasing, C. J., 4409 Roanoke Plwy., Kansas City 2, Mo. (Jan. '47) *M*

Blew, Michael J., 3405 Tulane Dr., West Hyattsville, Md. (Jan. '50) *MP*

Brown, Donald L., City Mgr., Sheboygan, Mich. (Apr. '49) *M*

Bryant Water Tank Service, E. H. Bryant, Mgr., Gen. Delivery, Odessa, Fla. (Assoc. M. July '46)

Carver, Leon A., City Mgr., Burkburnett, Tex. (Oct. '43) *M*

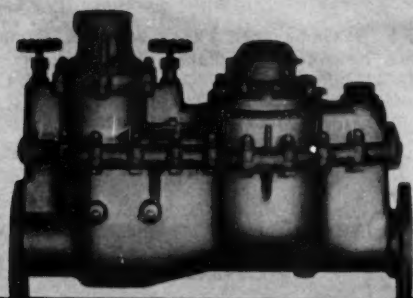
Coe, James G., Asst. Supt., Water Plant, 542 Frisco, Fayetteville, Ark. (Oct. '49) *MP*

Cowan, John G., 207 S. Broadway, Los Angeles 12, Calif. (Jan. '41) *R*

Dawson, Dick H., Becker Wood Products Co., Boulder, Colo. (July '47) *M*

De Vera M., Manuel F., Prof. of Hydraulics, Univ. of Havana, Lagarena 151, Havana, Cuba (Jan. '49)

(Continued on page 36)



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(Continued from page 34)

Dougherty, E. R., 111 W. Main St., Casey, Ill. (Jan. '43) *MP*

Ellingwood, Richard E., Pres., Soft Water Service Co., 913 W. Bridge, Spokane, Wash. (Oct. '49) *P*

Evans, Edmund Boyce, 2012 Lenox Dr., Dayton 9, Ohio (Jan. '27)

Fayetteville Water Plant, John E. Mahafey, Supt., Fayetteville, Ark. (Corp. M. Jan. '50) *MPR*

Fetherston, Florence, (Miss), Pres., Felton Water Co., Felton, Calif. (Apr. '49) *M*

Finke, Herbert A., Water Plant Foreman, 107 W. 2nd St., Huntingburg, Ind. (Jan. '51) *MPR*

Fortin, Joseph O., 188 Park Bldg., Glen Ellyn, Ill. (July '42)

General Chemical Div., Allied Chemical & Dye Corp., R. W. Ockershausen, Tech. Service, Edgewater, N.J. (Assoc. M. June '02)

Gibbs, Fred S., F. S. Gibbs, Inc., 2300 Washington St., Newton Lower Falls 62, Mass. (July '41) *P*

Gilbert, Marc, Civ. Engr., 31 McMahon, Quebec, Que. (July '49)

Greenland, J. A., Dist. Mgr., DeLaval Steam Turbine Co., 535—1st Ave., W., Seattle 99, Wash. (Apr. '49)

Grosboll, Lorin E., Sales Repr., Mueller Co., 2112 Dartmouth Pl., Charlotte 7, N.C. (July '48)

Hablik, Frank J., Sr. Asst. Supt., Bureau of Water Supply, 1316 Crofton Rd., Baltimore, Md. (Jan. '42)

Hall, Harry R., 5600—42nd Ave., Hyattsville, Md. (May '15) *Fuller Award '49. MR*

Hamilton, John J., Munic. Authority of Westmoreland County, 230 S. Pennsylvania Ave., Greensburg, Pa. (Apr. '50)

Harris, Monroe, Mgr., Pipe Dept., Johns-Manville Sales Corp., 1207 Architects Bldg., Los Angeles 17, Calif. (July '48)

Johnston Pump Co., Perry H. Brown, Chief Engr., 3272 E. Foothill Blvd., Pasadena 8, Calif. (Assoc. M. Jan. '49)

(Continued on page 38)



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(Continued from page 36)

Junction City Water Dept., V. A. Basgall, City Mgr., Munic. Bldg., Junction City, Kan. (Corp. M. Jan. '48) *M*

Kern, Kasper, Foreman, Water Service & Mains, Los Angeles Dept. of Water & Power, 6626 Hazeltine Ave., Van Nuys, Calif. (Apr. '51)

Kneer, Vernon R., 1101 Ottawa, Dayton 2, Ohio (Apr. '44)

LaMarre, Rene J., Flat Rock, Mich. (Jan. '35) *Director '47-'50.*

Lane, Carl D., 1755 Marinette Ave., Torrance, Calif. (July '47)

Laux, Paul G., Supt., Div. of Water, City Hall, Columbus, Ohio (Feb. '26) *MPR*

Lawrence, R. E., 2205 W. 49th Terrace, Westwood Hills, Kan. (May '28)

Lewis, John V., Director, Div. of Maint. Operations, Dept. of Public Works, 400 Dewey Ave., Rochester 13, N.Y. (Feb. '21) *M*

Lucey, Patrick J., 6355 S. California Ave., Chicago 29, Ill. (July '39) *MP*

Mahaffey, John E., see Fayetteville (Ark.) Water Plant

McCarthy, Edward J., Pres., Edward A. McCarthy & Son, Inc., Claypool Hotel, Indianapolis, Ind. (Oct. '49)

McNutt, Robert J., City Mgr., Hazel Park, Mich. (Apr. '49) *M*

Mitchell, Charles A., Repr., Calgon, Inc., 2625—6th Ave., S., Birmingham, Ala. (Oct. '49) *P*

Moffitt, William J., San. Eng. Asst., Dept. of Water & Power, 10809½ Wilshire Blvd., Los Angeles 24, Calif. (Jan. '51) *MPR*

Moore, Robert Condit, Engr., Elson T. Killam, Cons. Engr., 529 Millburn Ave., Short Hills, N.J. (Jan. '51) *PR*

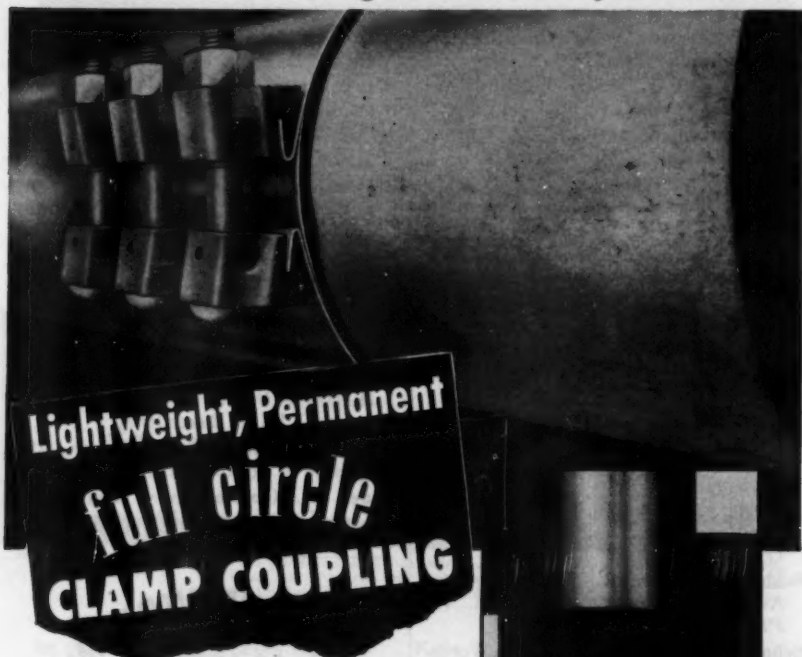
Morris, Robert Henry, Box 496, Ponte Vedra Beach, Fla. (July '48)

Muddiman, John B. C., 2108 Baringer Ave., Louisville, Ky. (July '39) *MPR*

Neese, L. Vincent, Sales Repr., Hersey Mfg. Co., 521 N. Wakefield Dr., Charlotte 7, N.C. (Apr. '50)

(Continued on page 40)

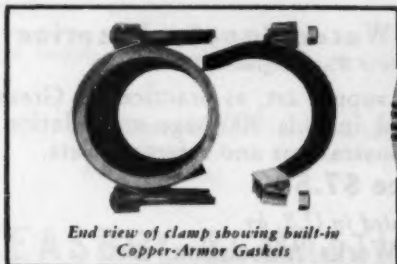
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(Continued from page 38)

- Niles, Charles A.**, Director of Sanitation, Suffolk County Dept. of Health, Bridgehampton, N.Y. (Jan. '45)
- Ockershausen, R. W.**, *see* General Chemical Div.
- Olsen, Carl Stanford**, Box F 376, Route 3, Bellevue, Wash. (Oct. '48) *MPR*
- Redwood, John P.**, Box 182, Niagara Square Station, Buffalo 1, N.Y. (Oct. '45) *MPR*
- Roahrig, Henry L.**, U.S. Special Tech. & Economic Mission to Thailand, c/o State Dept. Mail Room, Washington 25, D.C. (July '43)
- Rutherford, Kyle W.**, Asst. Engr., State Dept. of Health, State Office Bldg., Richmond, Va. (Oct. '49)
- Safford, M. A.**, Sales Engr., Wallace & Tiernan Co., Inc., Columbia Turnpike & Troy Rd., East Greenbush, N.Y. (Oct. '47)
- Schaeffer, John Joseph, Jr.**, Engr., Underwood & McLellan, Provost, Alta. (July '49) *P*
- Schindler, Richard R.**, 249 S. Highland Ave., Los Angeles 36, Calif. (Jan. '49) *PR*
- Schoepel, Walter C.**, Sales Repr., Worthington-Gamon Meter Co., 2624 Gracewood Ave., Cincinnati 24, Ohio (Oct. '46)
- Seufer, Paul E.**, 113901, Public Works Dept., Naval Shipyard, Navy No. 128, F.P.O., San Francisco, Calif. (Apr. '37)
- Shatto, Harry Howland**, Director of Public Works, City Hall, Hayward, Calif. (July '50) *M*
- Silverstone, Isadore Joseph**, 122-20 Boardwalk, Rockaway Park, N.Y. (Jan. '46) *PR*
- Smith, F. Burton**, Vice-Pres., Florida Utilities Corp., Box 791, Orlando, Fla. (July '43)
- Smith, Walter Hall**, 1208 E. Washington St., Boise, Idaho (Jan. '49) *MPR*
- Speir, William D.**, 335 S.W. 18th Rd., Miami 45, Fla. (Jan. '47) *MPR*
- Stewart, Spencer D.**, Proprietor & Mgr., Consolidated Water Co., 2750 W. Indian School Rd., Phoenix, Ariz. (July '47)
- Sutphin, Roy L.**, Blacksburg, Va. (July '50) *MP*
- Taylor, Harold D.**, 1865 Philomath Rd., Corvallis, Ore. (Apr. '48)
- Ulmer, Richard D.**, Hastings Terraces, Apt. 6A, 555 Broadway, Hastings-on-Hudson, N.Y. (Apr. '49) *P*
- Vergeer, C. S.**, *see* Baker (Ore.)
- Watkins, J. Stephen**, Cons. Engr., 251 E. High St., Lexington, Ky. (Aug. '33)
- Yoder, M. Carleton**, San. Engr., 1567 Terry Dr., Concord, Calif. (Jan. '49)



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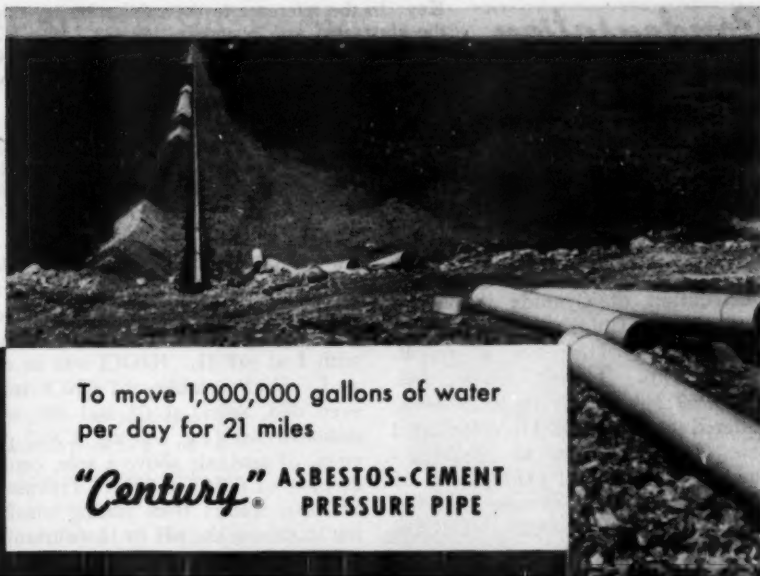
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If the publication is pagged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.*—*Bulletin of Hygiene (Great Britain)*; *C.A.*—*Chemical Abstracts*; *Corr.*—*Corrosion*; *I.M.*—*Institute of Metals (Great Britain)*; *P.H.E.A.*—*Public Health Engineering Abstracts*; *S.I.W.*—*Sewage and Industrial Wastes*; *W.P.A.*—*Water Pollution Abstracts (Great Britain)*.

POLLUTION CONTROL

Destruction of Cyanide in Waste Waters by Chlorination. G. E. EDEN, B. L. HAMPSON & A. B. WHEATLAND. *J. Soc. Chem. Ind. (Br.)*, 69:244 ('50). To KCN solns. buffered to a pH of 11, chlorinated lime (I) solns. equal to 2.0–2.4 g.-atoms of available Cl (II)/g.-mol. of HCN were added. Samples removed frequently, mixed with NaHCO_3 - Na_2AsO_4 soln. and analyzed colorimetrically with benzidine- $\text{C}_6\text{H}_5\text{N}$ reagent for CNCl. Linear relation of log of the CNCl concn. against time, extrapolated to 0 min., indicated all CN initially converted to CNCl which rapidly hydrolyzes when excess of I is present. While only 2.2 g.-atoms of II was taken up per g.-mol. HCN at pH 11.80 and up to 40 hr., the II consumption rose to 5.75 g.-atoms in 2.5–11 min. at pH 8.18 as pH falls. Reaction of KCNO with I showed same pH dependency, suggesting that II in excess of 2 g.-atoms per g.-mol. HCN required to form CNCl is not directly used by CN, and further oxidation occurs only after CNCl has been formed and, perhaps, hydrolyzed. Excess II consumption shown to produce nitrate and CO_2 . CNCl completely oxidized in 15 min. with 0.5 g.-atoms of II per g.-mol. of CNCl at pH 8.93 and 9.89, while at pH 7.03 and 7.96 no complete reaction of CNCl occurred after initial CNCl reaction to an equil. concn. Zn and Cd cyanides destroyed rapidly at pH 11 with 2 g.-atoms of II per g.-mol. of HCN, while $\text{K}_2\text{Cu}(\text{CN})_2$ required excess of II to oxidize Cu^+ to

Cu^{++} ; $\text{Ni}(\text{CN})_4$, not completely destroyed except in 2 hr. or more with 4.0–6.0 g.-atoms of II per g.-mol. of HCN, while $\text{K}_2\text{Fe}(\text{CN})_6$ did not react with I at pH 11. NaOCl was as eff. as I. High volatility of CNCl from even dild. solns. at 0° and 20° was demonstrated (e.g. 400 mg. CNCl per cu.in. of satd. air above a soln. contg. 20 ppm. of CNCl at 20°). Treatment of waste waters from plating consisting in raising the pH to 11 (nitramine indicator), adding slight excess of I (starch-I₂ paper), allowing time to oxidize, and testing for CNCl with Aldridge reagent, shown to be satisfactory. After metallic hydroxides settled and supernatant liq. decanted and neutralized, effluent was not, or only very slightly, toxic to fish (rainbow trout), perhaps because of residual metal content.—*C.A.*

The Effect of Phosphorus on the Decomposition of Organic Matter in Fresh Water. C. B. TAYLOR. *Proc. Soc. Appl. Bact.*, 2:96 ('49). Investigations carried out on factors which affect decomp. of organic matter in water, to find what substances limit bact. growth. Bact. activity was measured by the amt. of oxygen consumed after incubation at 20°C. for a known period. Sometimes lake water used, and sometimes disd. water to which certain substances were added. Showed the rate of decomp. of org. matter depends on concn. of phosphorus present. Inorganic phosphates also proved effective. If iron was present decomp. was retarded, suggesting iron-phosphate complexes are not

(Continued on page 44)

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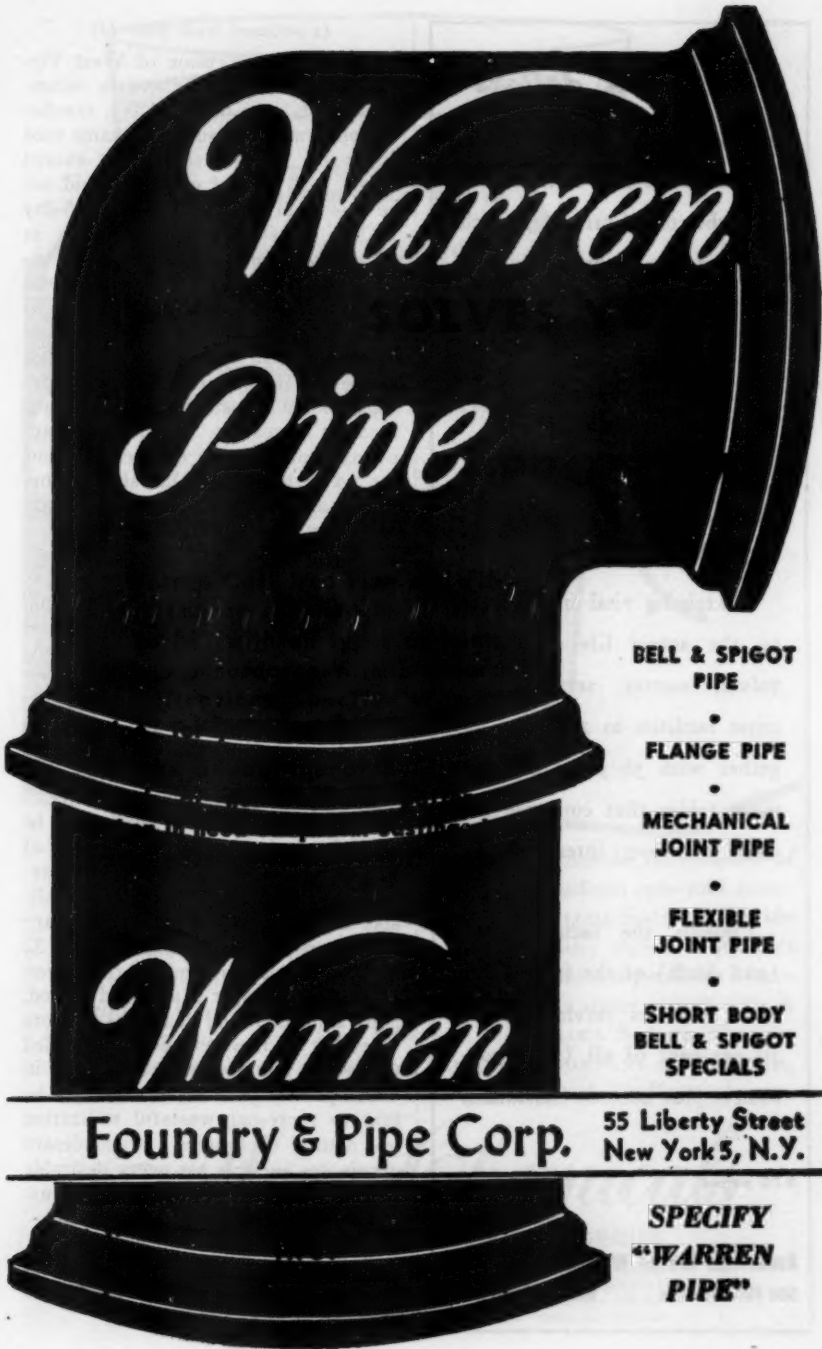
(Continued from page 42)

readily broken down by bact. Amt. of oxygen used by natural waters could be increased by addition of glucose alone. Concluded that phosphate required for decomp. processes is combined with org. matter and activity of bact. in lake waters controlled by amt. of org. material available, but any great increase of such material will soon lead to condition in which phosphorus is limiting factor.—*W.P.A.*

Soil Conservation and Stream Pollution. H. H. BENNETT. *Unpublished paper presented at meeting sponsored by Interstate Com. on Potomac River Basin, Apr. ('49).* Discusses causes of soil erosion and describes polg. effects of silt on receiving water, with particular reference to conditions in Potomac River basin. Troubles caused by poln. of streams by silt include damage to fish and shellfish, destruction of plankton, silting of reservoirs and waterways, and difficulties in treating water for industrial and domestic supply. Considers only effective method of controlling this type of poln. is to prevent soil erosion.—*W.P.A.*

Standards of Stream Sanitation. H. W. STREETER. *Sew. Wks. J., 21:115 ('49).* Recent trends in proposed stds. for the qual. of water in streams, particularly in the Ohio and Potomac River basins, discussed, and present practice in use of stds. in the U.S. described. Information from 45 state depts. of health showed in 10 states standards have been officially adopted, and in 15, stds. are used although not enforced by legislation. Stds. of 22 states based on maintg. satisfactory conditions in streams for subsequent use of water for various defined purposes. Bact. and chem. stds. recommended by authorities controlling the Ohio River basin, Tennessee valley, West Virginia, and the Potomac River basin are given in a table and com-

(Continued on page 46)



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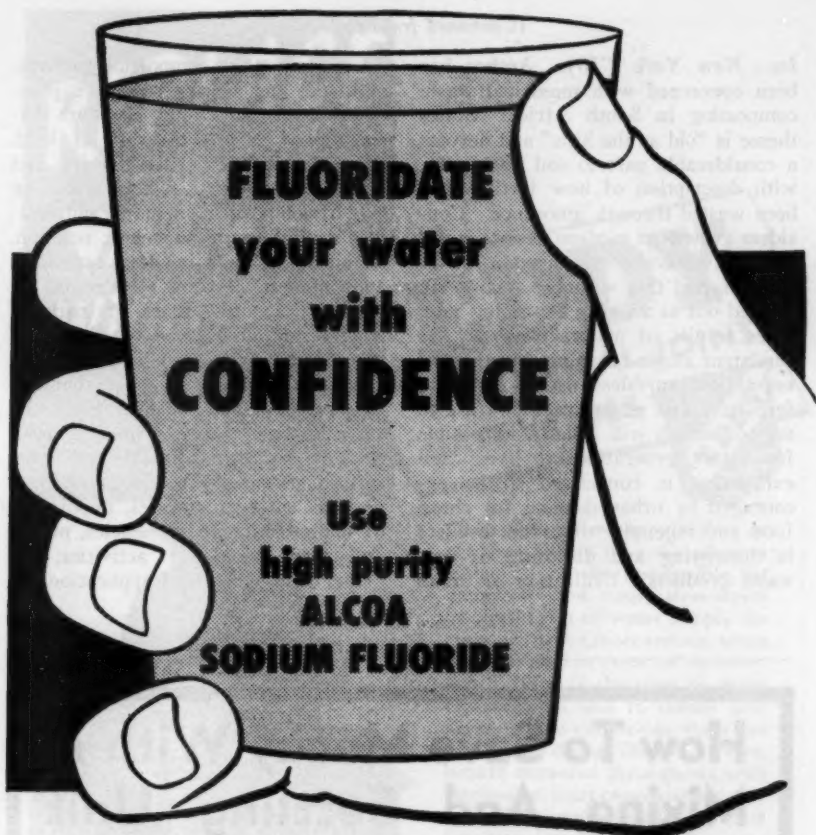
(Continued from page 44)

pared. With exception of West Virginia Water Com., authorities recommend that, on a monthly avg. number of coliform organisms in streams used for water supplies should not exceed 50 ml., the content of d.o. should not be less than 6.5 ppm. and the 5-day B.O.D. should not exceed 3 ppm. in Ohio River basin and 2 ppm. in Tennessee valley and Potomac River basin. Bacteriologically the stds. of the West Virginia Water Com. are more stringent (10 coliform organisms/ml.) for streams used for water supplies and less stringent for streams used for recreation. Possibility of applying same stds. in different regions for water to be used for similar purposes, and future trends in stream sanitation discussed.—W.P.A.

Stream Sanitation in Florida. E. B. PHELPS & D. E. BARRY. Florida Eng. & Ind. Expt. Sta. Bul. Series No. 34 (May '50). Water qual. specifications given for water usage by different interests, such as domestic supply, bathing, shellfish growing and industrial needs, followed by a description of natural, reversible, self-purification stream reactions. Statistical treatment of drought flows given may be helpful to others making estimates of min. flow conditions in streams, particularly those with incomplete available data. Part devoted to summary of stream flow and poln. data on 32 major Florida streams. Area, mean and min. flow over a specified period, pop. and industrial load are factors listed for each watershed. Concluded that while there were certain areas in which present pold. condition might be said to represent wasteful utilization of natural resources, preponderant group was suitable for every desirable purpose of recreation, wild life, industry, and domestic use.—P.H.E.A.

Soil Fertility and Sewage. J. P. J. VAN VUREN. Dover Publications,

(Continued on page 48)



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(Continued from page 46)

Inc., New York ('50). Author has been concerned with municipal waste composting in South Africa. States theme is "old as the hills" and devotes a considerable part to soil husbandry, with description of how fertility has been wasted through ignorance. Considers growth of modern deserts is not result of natural conditions, but caused by man, and that wasteful actions are carried out at an ever increasing rate. Cites results of malpractices such as persistent single cropping, burning off vegetation, ruthless use of artificial fertilizers and ploughing all refuse to the soil which will make it impossible for future generations to live. Soil exhaustion is considered to be encouraged by urban demand for cheap food and ingenuity of urban dwellers in destroying and disposing of org. waste products. Utilization of urban

waste products by composting garbage, nightsoil, and sewage sludge, a practice followed in Union of South Africa, helps restore fertility of land. General principles of composting and effects of various factors affecting rate of composting, including pulverizing, rainfall, aeration, temp., reaction, suitability of plant residues, activators and mineral nutrients illustrated by results and chem. anal. of material. Studies and observations on fly breeding given. Certain methods of composting recommended and labor requirements and costs calcd. Phys. and chem. characteristics of finished product and significant fertility value described. A chapter on the general importance of org. manures, importance of humus, mineral deficiencies, micro- and macro-biological activities, together with methods of application and

(Continued on page 50)

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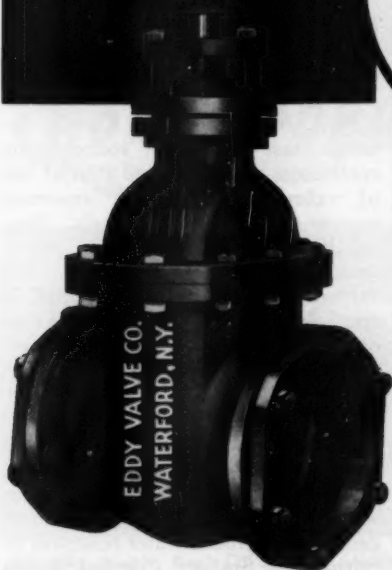


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responses, concludes this unusual book. Thesis of book is underlying principles of Chinese agriculture are sound, but practice unsanitary, and proper composting produces gratifying results. Book interesting, semi-scientific, and expressions of enthusiasm and faith. Recommended to all who have interest in future of country and are immediately concerned with preparation, handling and disposal of human wastes.—*P.H.E.A.*

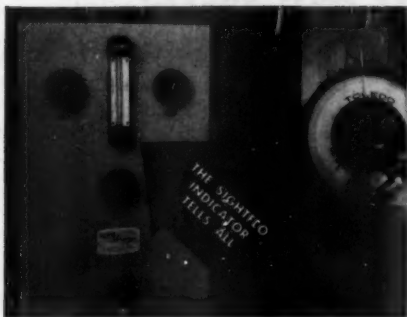
GROUND WATER

Subsurface Reconnaissance of Glacial Deposits in Northeastern Kansas. J. C. FRYE & K. L. WALTERS. Univ. of Kansas Pub. Bul. 86, Pt. 6:15 ('50). In northeastern Kansas, deposits made directly or indirectly by continental glaciation, and alluvial fills of valleys are the most important sources of ground water supply. During 1948 and '49 a subsurface reconnaissance of deposits was made. Results of work, including records of 64 test holes, are described and presented on cross sections. Stratigraphic sequence is described.—*P.H.E.A.*

Geology and Ground Water Resources of Barton and Stafford Counties, Kan. B. F. LATTA Univ. of Kansas Pub. Bull., 88 ('50). Presents the results of an investigation of geology and ground water resources of Barton and Stafford Counties, begun in July 1942, by the U.S. Geological Survey and the State Geological Survey of Kansas, with cooperation of the Div. of San. of the Kansas Bd. of Health and the Div. of Water Resources of the Kansas Bd. of Agriculture. Owing to the concn. of survey activities on war work and shortage of personnel, field investigation was interrupted and not completed until the fall of 1944. Importance of ground water indicated by fact that entire population of Barton and Stafford Counties

(Continued on page 52)

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(Continued from page 50)

obtains water supply from wells. Wells also supply water for livestock, industrial use, and irrig. of more than 1,500 acres of land. There is, thus, definite need for understanding of this important natural resource. Investigation in Barton and Stafford Counties made to determine quality, quantity, movement and availability of good water.—P.H.E.A.

Method to Obtain Capillary-Held Water From Sandy Soils. R. WIND HZN. Water (Neth.), 35:35 ('51). An app. to det. the capillary-held water from dune soil with little or no disturbance of the soil in samples. Consists of steel tube (105 cm. long, 15 cm. id.) lined with copper, driven into soil with a rammer (33 kg.). Careful pulling allows sand to adhere to inside of tube which is then closed at lower end with a copper lid and bayonet catch. Middle of lid is perforated with small hole. In the lab., 250 ml. of fluorescein soln. (1 ppm.) is poured on sand in tube twice daily. The added water will drive out "held" water, which usually starts seeping out after about 4 days. The colorless water is collected and anald. Variation in 60 samples was 150-700 ml., averaging 400 ml.—W. Rudolfs.

The Salt-Water Problem in Texas. W. O. GEORGE. World Oil, 130:2:56 ('50). Water for public supplies in Texas obtained from depths ranging from 10 to about 4,200 ft. Most common source of poln. of ground water is salt water leaking from earth pits used for storing salt water separated from oil.—W.P.A.

Corrosion and Chemical Testing of Water for Subsurface Injection. J. W. WATKINS. Producers Monthly, Pt. 1:15 (Feb. '50). Detailed description of methods of corrosion test and chem. anal. that have been used extensively and satisfactorily in a study

(Continued on page 54)



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(Continued from page 52)

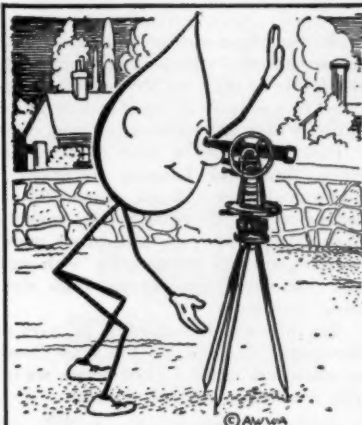
of plants that treat various surface waters and brines used for water flooding, brine disposals and reservoir pressure maint. in Kan., Okla. and N. Tex. Tests and anal. described were adapted and designed for field use to det. relative corrosive and plugging tendencies of waters from various sources conditioned by different methods.—*Corr.*

HYDROLOGY, CONSERVATION & IRRIGATION

Irrigation and Glaciology. A. DAVID. *L'Eau (Fr.)*, 38:35 (Mar. '51). A study of important needs of irrig. water of lower Durance Riv. basin (SE Fr.) in relation to ominous regression, especially during the last decade, of the glaciers from which river originates. Although strict water needs amt. to 2,980 cfs., and

actual (safe) needs to 3,900 cfs., in the last 10 yr. the Durance has yielded only 1,410 cfs. (monthly avg.) in July, Aug. and Sept., when irrig. needs are greatest. Meanwhile, Feeding glaciers, which are the chief source of the summer flows (snow melts earlier) have shown an avg. decrease in surface area of 47% (64% for south side glaciers, 32% for North Side ones), and a regression of glacier front of 100 yd. accompanied by a settling of 36½ ft. in 2 yr. Need for better studies in glacier decrease is stressed to warn of near critical state of conditions. Establishment of a proposed water conservation area, including 2 dams to preserve the irrigd. regions is recommended because "a decade similar to one just experienced would destroy (glaciers) almost completely."—*M. Albanese.*

(Continued on page 56)



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(Continued from page 54)

Filtering Power of Soils, and Irrigation. CHARLES THIRON L'Eau (Fr.), 37:125 (Sept. '50). Result of a field application of the improved Muntz method of detg. the filtering power of soils. Tests were conducted in southwestern France, near Tautavel, as part of a prelim. study for an irrig. project in this wine-producing region. Soils considered composed of marls, clay, silt, coarse and fine sand, with clay and fine sand dominating and some limestone pebbles present in certain specimens. Total of 34 measurements of filtering power of soils, from 105 min. to 3.5 hr. each, showed 85% of the soils having Muntz values of 0-10 and 15% of 10-20 (filtering power increases with Muntz value). Whereas "min. filtering power" notation shows 85% in 1-10 range, 12% in 10-20 range, "max. filtering power" notation provides similar results. Percolation showed max. penetration of 15 cm. in 3.5 hr. water movement—vertical and lateral—attributed to settling of soils. Soils quite impervious and fit for conveying irrig. water. Filtering power variations attributed to presence or absence of coarser elements. Curves of filtering power (in Muntz Units) against filtration time are straight lines. Extrapolation of curves for shorter filtering periods considered satisfactory practice by the author.—M. Albanese.

A Hydrological Observation on Lysimeters of the Provincial Water System Noord Holland. Z. VAN DOORN. Water (Neth.), 35:23 ('51). Ten years ago 4 large lysimeters (25 × 25 meters) were constructed in dunes near Castricum. Data collected on daily rainfall and drainage to det. influence of different kinds of vegetation on drainage capac. One received 20 kg. KCl as fertilizer. Effect of KCl on corporation of the drainwater led to following observations: [1] time and quantity of rainfall necessary

(Continued on page 58)

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(Continued from page 56)

for the KCl to appear in the drain-water—4 mo. and 180 mm.; [2] effect of daily rainfall on daily drainage by means of displacement—3-10 days; [3] water storage capacity of dune sand is above ground water level or about 10% of total sand mass above ground water level.—*W. Rudolfs.*

Problem of Artificial Control of Rainfall Over the Globe. TOR BERGERON. *J. Inst. Wtr. Engrs. (Br.)*, 4:10 (Feb. '50); reprinted from *Meteorological Mag.*, 78:330 ('49). There is now possibility of controlling weather to some extent. Only attack on inducing pptn. has been dropping artificial nuclei into clouds. Man might warm oceans by atomic energy to induce evapn. Only cloud forms with thermodynamic instability are generally capable of inducing appreciable pptn. Situation necessitates water in all 3 phases of evapn. and condensation at temp. below 0°C. to be efficient. Artificial seeding has little value in producing pptn. from ordinary stratiform or cumulus clouds. Seeding of frontal clouds hardly practicable. Best prospect for seeding is with cloud produced by strong upward motion, more or less fixed in space, and extending above 0°C. level but not reaching 10°C. level. Outside tropics heavy pptn. requires low cloud formation, resulting from intense up-draft at high temp. in continuous contact with upper cloud above -10°C. level, or artificially seeded. Frictional convergence in static, stable air streams flowing roughly parallel to an even low coastline can produce coastal max. of pptn. Such orographic cloud systems, if lacking efficient natural release, represent clouds in which artificial seeding might increase pptn. materially. Increased coastal pptn. would diminish inland pptn. where needed. Both technical and political difficulties are thus liable to be created.—*H. E. Babbitt.*

(Continued on page 60)

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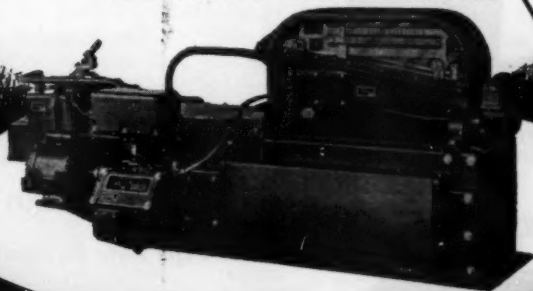
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(Continued from page 58)

WATER SOFTENING

Water Softening. Ministry of Health. H.M. Stationery Office, London ('49). Report of Water Softening Subcommittee of Central Advisory Water Committee on practicability of softening water in areas where there is a high degree of hardness discussed following subjects: cause and detn. of hardness in water, hardness of water supplies in Great Britain, effects of water hardness on health, soap consumption, and scale formation methods of overcoming disadvantages of hard water (use of synthetic detergents instead of soap, and use of domestic water softeners, soda, and other softening agents), methods of reducing scale formation, effects on industrial consumers of softening public supplies centrally, operation and costs of lime

and base-exchange processes of softening, and corrosive properties of softened water. Softening at plant is desirable when water has a hardness greater than 200 ppm., but at present often impracticable. Est. given of amt. of soap wasted by using hard water. Factors affecting deposition of scale and the effect of scale on eff. of heating. Types of domestic softeners described and their maint. and costs discussed. Equations given to represent chem. reactions which occur during removal of hardness, and potassium palmitate and soap tests for determining total hardness.—*W.P.A.*

Apparatus for Obtaining Fresh Water From Sea Water. WILLIAM A. E. HULT. U.S. 2,546,071 (Mar. 20, '51). App. provides for treatment of sea water with compd. AgNO_3 in an

(Continued on page 62)



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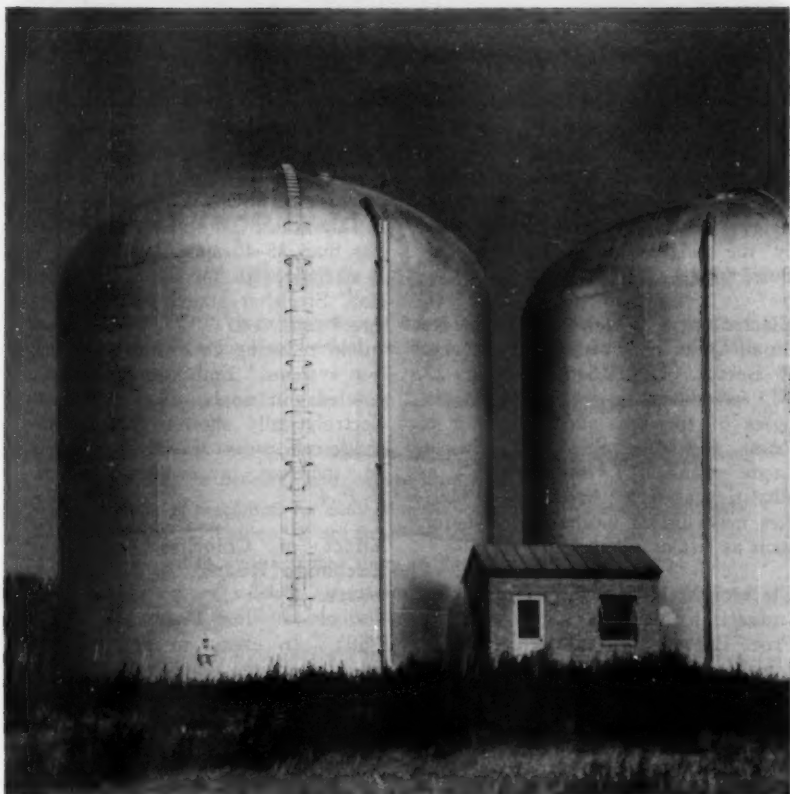
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(Continued from page 60)

agitator and passage of treated water through a "rifle barrel" sluice pipe to recover resultant ppt. of AgCl. Settling tank receives treated water from which more AgCl is pptd. Water is then led into evapg. ponds for extraction of compd. nitrates or for use as irrig. water. Pptn. is greatly aided by the ridges and corrugations of sluice pipe.—C.A.

Electrolytic Water Softener for Small Quantities of Water. ROBERT E. BRIGGS. U.S. 2,546,254 (Mar. 27, '51). Sufficient hydrostatic head disposes of the ppt. and utilizes it to maint. a predetermined pH value in anode chamber (with $\text{Ca}(\text{OH})_2$ as alkalizing agent). Arrangement obviates necessity of mechanical transfer, such as lift or pump.—C.A.

Electrolytic Water Softening for Industrial Purposes. R. E. BRIGGS. Proc. Engrs. Soc. Western Pennsylvania 109 ('45). Discusses softening of water by electrolytic treatment. May be effected in 2-compartment cell with single diaphragm with carbon or graphite anode and cathode of black iron. Water flows through cathode section of cell where it becomes alkaline; calcium, magnesium, and some other positively charged ions and hydrogen evolved. Ions, such as chloride and sulfate, migrate to anode section, from

which water is discarded. Water from cathode section, which has a pH value of 10.0–11.5, settled, filtered, and treated to adjust pH value. When large vols. are to be treated is advisable to have series of cells arranged for parallel flow. When water is cold is impractical to reduce hardness to less than 35–40 ppm., but greater eff. is attained with hot water. In discussion, Streicher stated, as process reduced content of d. o. it would be helpful in reducing corrosion in distribution systems. Embshoff & Gustafson pointed out anals. of water treated electrolytically showed that, when a single-cell system was used, there was an increase in sodium content.—W.P.A.

Effect of Chlorine on Cation-Exchange Resins. D. G. BRAITHWAITE, J. S. D. AMICO & M. T. THOMPSON. Ind. Eng. Chem., 42:312 ('50). In expts. to find effect on cation-exchange materials of chlorine used for disinfecting water, 10 g. of each exchange material tested covered with 100 ml. of water containing 100, 200, 500, or 1,000 ppm. chlorine. Pure hydrocarbon resins, such as sulfonated styrene-divinylbenzene polymers, not attacked by any concn. of chlorine but were bleached by contact. Sulfonated phenol-formaldehyde resins or carbonaceous materials attacked by chlorine

(Continued on page 64)

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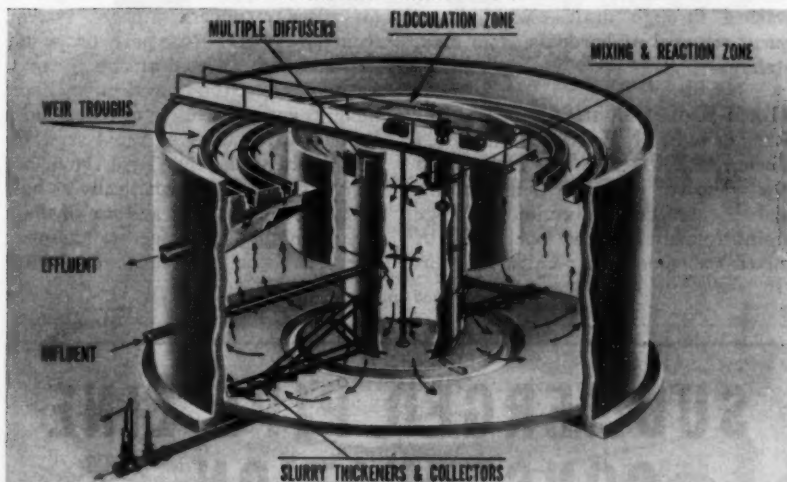
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(Continued from page 62)

and products formed as result of attack colored water. Concentrations of chlorine which attacked exchange materials in excess of those normally found in water supplies. Source of chlorine is unimportant, similar results obtained with chlorine water and sodium hypochlorite solutions and calcium hypochlorite. Discusses theory of probable mechanism of attack.—*W.P.A.*

Water Softening by Electrolysis.

GERALD R. COLLINGS. (Br.) 648,201 (Jan. 3, '51). An electrolytic app. comprises two low cond. C-filled upright cylinders, with anode and cathode in bottoms, resp. Water enters one some distance above electrode, passes out top into conduit connecting at a similar height above bottom of second vessel, from top of which final effluent emerges. Intermediate electrodes connect across tops of cylinders. As electrolytes conc. around the anode and cathode regions, water is washed through drains, with consequent removal of hardness from main stream.—*C.A.*

Mixed-Bed Deionization. A. C. REENTS & F. H. KAHLER. Ind. Eng. Chem., 43:730 ('51). Availability of low density anion-exchange resins and higher density cation-exchange resins made possible operation of mixed-bed deionizing units. Resins

can be regenerated in same units. Operating procedures for 6 methods of regeneration compared in cost, capac. and eff. Comparison of mixed-bed technique with conventional two-bed deionization shows mixed-bed superior in saving in water consumption, regeneration time, space economy, eff. of operation in time operation after standing and resistivity of effluent of the unit. A mixed-bed unit combining strongly acid cation resin and strong base anion exchanger produced water with av. resistivity 20 times higher than other combinations with raw water influent, and av. resistivity 6 times higher with synthetic water influent.—*C.A.*

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The Hydraulics of Rapid Sand Filters.

GORDON M. FAIR. J. Inst. Wtr. Engrs., 5:171 ('51). The six elements in hydraulics of rapid sand filters are: sand bed, supporting layer of gravel (if used), under-drainage system, scouring system (as part or whole identical with under-drainage system), wash-water collection system, ancillary conduits and appurtenances. Concludes although hydraulics of rapid sand filters fairly well formulated, have not been explored as systematically as half century of eng. design and use of these filters might lead one to assume. There is a challenge, in particular, to

(Continued on page 66)

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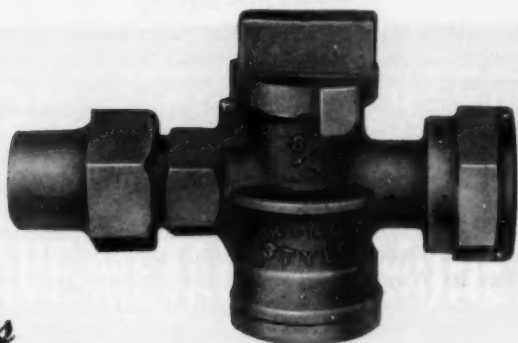
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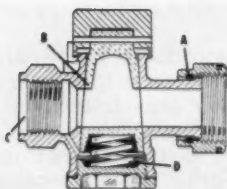
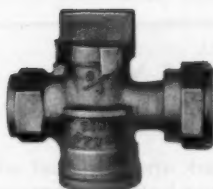
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(Continued from page 64)

explore further requisite depth of filter sands of differing sizes, make all sand do approx. same amt. of work, render sand thoroughly clean by each washing and devise methods of wash-water distr. and filtered water collection that will ensure greater equality of bed performance.—C.A.

Does Surface Wash Equipment for Sand Filters Pay Its Way? EDWARD S. HOPKINS. Pub. Wks., 81:12:35 ('50). Palmer sweeps installed in 2 Baltimore, Md., filters to det. effectiveness and economic value. Results after 6-mo. operation: sweep-washed filters consumed more wash water, passed 2.3% less water and showed shorter filter runs. Sweeps justified, however, by elimin. of annual manual sand cleaning costing \$186.56/filter. Installed cost of 8 sweeps/filter \$2,624.16. Cost of excess wash water/

filter with sweeps \$5.86, leaving net cleaning cost/filter \$180.76. If sweep investment computed at 2.0%, net annual saving using sweeps is \$128.28.—F. J. Maier.

Reuse of Diatomaceous Filter Aid in Water Treatment. LAURENCE E. WEYMOUTH (to Johns-Manville Corp.) U.S. 2,542,743 (Feb. 20, 1951). If diatomaceous earth filter aid is reused without treatment retained alum floc greatly impedes flow of water through bed. After fourth reuse the flow rate dropped to 18% of original. By heating used filter aid within the temp. range 220–600°F., in order to destroy gel structure of entrapped floc by reducing the water content to not more than 2–8%, the product may be reused about 10 times without serious impairment to filtration performance. Continuous increment of about 5–10%

(Continued on page 68)



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MEETS A. W. W. A. SPECIFICATIONS



(Continued from page 66)

of fresh filter aid, added to the precoat, with corresponding discard of used material recommended.—C.A.

MISCELLANEOUS

Basic Considerations on Protective Coatings on Lead and Lead Solubility in Drinking Water. JOHANNES MÜLLER. Gas-u. Wasserfach, 92:39 (Feb. '51). Protective coating formation differs in lead pipes from that in iron pipes in [1] the corrosion reaction, which is a simple oxidation in lead pipes; [2] the production of alky. at pipe surface and subsequent reaction of CO_2 with corrosion products; and [3] the purpose of protective coating formation, which in lead pipes is the prevention of toxic consns. of lead reaching the consumer. Water may take up lead by chemical reaction with

and mechanical removal of pipe deposits, and by diffusion through pores of deposit to react with the metal. Pipe deposits may be suspended in the water during sudden changes in pressure. Colloidal suspensions of lead corrosion products occur most frequently in new pipes.—Peter K. Mueller.

Disinfection of Water Supplies and Distribution Systems. JOSEF HOL-LUTA. Bau u. Betrieb, 3:1 (Jan. '51). Disinfection of water supplies is necessary for water to reach the consumer free from bacteria and to protect against reinfection in the pipes; methods should be noncorrosive. Most common chlorination methods used are: Cl_2 solns., NaClO , KClO , $\text{Ca}(\text{ClO})_2$, $\text{Mg}(\text{ClO})_2$, $\text{CaCl}(\text{ClO})$ and Cl_2 and NH_3 . With Cl_2 and NH_3 ,

(Continued on page 70)



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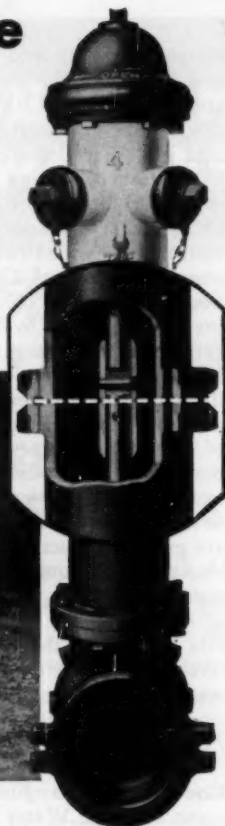
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(Continued from page 68)

the active constituents may be NH_2Cl and NHCl_2 . If the active constituents are HClO and ClO_2^- , the relative concns. are governed by pH. At an acid pH the relative concn. of HClO is greatest, coinciding with the shortest killing time. At the same pH, the killing time of chloramines is longer than that for direct chlorination. The amount of residual Cl_2 desired for a clean, clear water contg. no coliform organisms is detd. by considering pH, permanganate demand, and carbonate hardness. For more contamd. waters, the amount of Cl_2 residual required is detd. by Pick's method. The method of chlorination to be used depends on the nature of the distribution system, location of consumers, and detention time in distr. system. General rules are given. Reduction of alky. by chlorine and chloramines may make the water corrosive. Corrosion at point of mixing can be minimized by rapid diln. Knowing the alkalinity, the effect of Cl_2 on the corrosiveness of the water can be determined. Hypochlorite solns. increase pH of water.—*Peter K. Mueller.*

Contribution to Judicial Management of Dune Water Supply. P. C. LINDENBERGH. Thesis. Leiden, Netherlands ('50). Not more than 400 mm. per year effective pptn. can be removed from the dune supply by proper, expensive methods. In certain sections of the dunes, wells can be driven, especially in areas where layers of impervious soil are present at low depth. The area of the Leiden Dune Supply Co. has been increased by wells to about 2000 acres capable of a safe yield of 3,200,000 cu.m. a year. With intermittent flooding, the yield can be increased at least 3 times. The flood water can be stored in the dune sand sufficiently long to make maximum use of the spring rains. To make proper use of the water storage capacity of the sand approx. 1,500,000 cu.m. of water must be pumped into about 250

acres each year. This area must be protected to prevent water losses, and the water used for recharge must be of a high calibre to prevent contamn. and protect the pipelines. The distance from the flood water to the recharge area must be at least 50 m. to be sure that the recovered water is safe. The chemical compn. of the recharge water changes little; color and taste are improved. Recharge has a beneficial effect on the flora and fauna of the area and aids agriculture and bulb fields at the foot of the dunes.—*W. Rudolfs.*

OTHER ARTICLES NOTED

Considerations Preliminary to the Determination of the Minimum Lethal Dose for Fish of Some Substances of Harmful Character. EDM. LECLERC & F. DEVLAMINCK. Bull. Centre Belge Etude et Document Eaux (Liege) 8: 483 ('50).

Chemical Treatment of Water. A. H. WADDINGTON. Contractors' Rec. 59: 1:14; 5:11; 8:11; 12:11; 19:11; 28:27 ('48).

The Determination of Small Oxygen Contents Dissolved in Water. JEAN VERBESTEL, ARMAND BERGER & VALERE ROYER. Bull. Centre Belge Etude et Document Eaux (Liege) 8:494 ('50).

Colorimetry and Absorptiometry. ARMAND BERGER & JEAN VERBESTEL. Bull. Centre Belge Etude et Document Eaux (Liege) 8:503 ('50).

Colorimetric Determination of Aluminum in Water by Means of Ammonium Aurin Tricarboxylate. A. C. ROLFE, F. R. RUSSELL & N. T. WILKINSON. J. Applied Che. (Br.) 1:170 ('51).

Investigations on the Biological Purification of Swimming Water. E. D. A. SINDRAM. Dissertation p. 145 Univ. Amsterdam ('47).



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(Continued from page 18)

Salting away, which has always meant saving up, really means saving up nowadays—saving up rain, that is, to prevent its falling in well-watered coastal areas to permit its falling farther inland. All this is a further refinement of the art of rainmaking whereby, by overseeding the warm coastal clouds with rock salt, the growth of raindrops is stunted until the clouds pick up more moisture on their way inland. What it means is that a lot of unhappy people, such as those in five Colorado mining towns who recently petitioned their governor to call a halt to rainmaking because it collapsed their diggings, will have a weapon with which to fight back. When too much rain threatens, all they'll have to do is trundle out their generators, stoke them with coke, toss in some salt and start seeding. The generators vaporize the salt, then project it out at high velocity, which causes it to cool quickly in the form of fine solid particles that are carried into the atmosphere by upward wind currents. Properly sprinkled, the salt particles create an imbalance between nuclei and moisture in the cloud and, practically presto, sunshine . . . well, anyway, flood control!

Poised on the brink of our own vacation, we've already reserved a burner and plan to cook up a continuous current of condiment in the hope of guaranteeing fair fairways. We've already wished ourself a happy holiday seasoning.

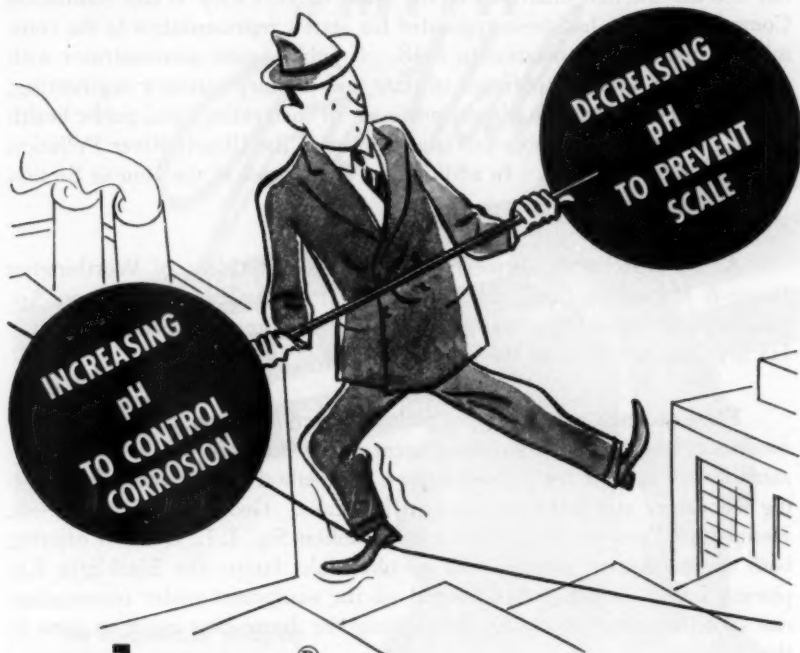
Rainmaking and unrainmaking, both, we're a bit up in the air about our raw material. Ever since Assistant Attorney General Bruce Allen of Texas ruled that moisture in the air is not a natural resource, we've been a little queasy about handling the stuff—at least until we've determined whether it's un-, sub- or supernatural. Of course, the general was interested only in preventing two county water districts from entering into rainmaking contracts with a cloud seeding firm, but the reverberations, we think, are going to make like a real thunderstorm.

Lawrence K. Cecil has been elected vice president of Infilco Inc. He had joined the firm 25 years ago and has served as sales engineer, district manager and, since 1950, general sales manager.

Gordon E. McCallum has been appointed chief of Health Emergency Planning for the U.S. Public Health Service. Established in 1948 to plan for more comprehensive public health catastrophe services, this office works closely with the Federal Civil Defense Administration and other organizations working on civil defense planning. McCallum has worked with this office since its inception. He has also served as consultant to the National Labor Relations Board and the Dept. of Defense since 1948, and is the U.S.P.H.S. liaison officer with the Federal Civil Defense Administration.

(Continued on page 74)

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(Continued from page 72)

Clarence W. Klassen, chief sanitary engineer of the Illinois Dept. of Public Health and technical secretary of the state's Sanitary Water Board, has become the new chairman of the Ohio River Valley Water Sanitation Commission. He had been appointed his state's representative to the commission upon its organization in 1948. A public health administrator with more than 25 years' experience in state and military sanitary engineering, he also holds the post of assistant professor of bacteriology and public health at the University of Illinois and is a member of the Illinois River Pollution Legislative Commission. In addition, he is a trustee of the Illinois Section of A.W.W.A.

A. H. Borchardt, formerly assistant vice president of Worthington Pump & Machinery Corp., and also manager of its Centrifugal Pump Application and Sales Div., has been elected a vice president of the company. He is a past president of the Hydraulic Inst.

Fluorescence can be applied to leak detection in condensers and other containers into which a fluorescing agent can be introduced. Although presumably not suitable for potable waters, the method may be of use in checking laboratory and testing equipment for leaks. George W. Gates & Co., Hempstead Turnpike & Lucille Ave., Franklin Sq., L.I., N.Y., is offering both the fluorescent solution and an ultraviolet lamp—the Blacklight Exploring Lamp—which, when trained on the equipment under observation, can spot the points of leakage by exciting the fluorescing agent to glow in the dark.

The complete business and manufacturing facilities of the Geophysical Instrument Co. have been acquired by Georator Corp., Arlington 9, Va. The Geophysical Instrument Co. Div. of the latter organization will continue to produce the same geophysical instruments.

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Service Lines

A description of three pipeline protective wraps offered by Owens-Corning Fiberglas Corp., Toledo 1, Ohio, is contained in a booklet just issued. In addition to the usual inner and outer wraps, a special rock shield is offered for use in rocky terrain, or where pipe encounters rough treatment.

The application to large pumps of a-c. motors is the subject of the latest issue, No. 33, of the quarterly *E-M Synchronizer*, available from Electric Machinery Mfg. Co., Minneapolis 13, Minn.

"Fundamentals of Industrial Electrochemical Measurements and Automatic Control" is the title of a 24-page technical bulletin, No. B51-2, published by the Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa. Among the factors discussed is pH value.

Brush and weed control by chemical application is the subject of an operations manual published by the Grasselli Chemical Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

Abrasive wheels are the subject of a technical report issued under the title of "Selection, Care and Maintenance of Abrasive Wheels." Written by Joseph De Feher of the Office of Technical Services, the folder is No. 8 in the series of *Defense Production Aids* issued by the National Production Authority's Office of Small Business, Washington 25, D.C.

(Continued on page 78)



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(Continued from page 76)

Pipeline repair products offered by Stauffer Mfg. Co., 2453 Merced Ave., El Monte, Calif., are featured in a new catalog and price list. The bulletin is called "Stop That Leak."

A technical information folder entitled "All You Need" has been offered by A. P. Smith Mfg. Co., East Orange, N.J., to explain the installation of the Smith cut-in valve and sleeve.

"Products and Processes for Industry" is the title of a new catalog issued by Inflico Inc., Box 5033, Tucson, Ariz. The 12-page booklet contains information on equipment for chemical feeding, coagulation, precipitation, filtration, softening and other treatment processes. Applications and descriptions of the apparatus are provided in the bulletin, which is known as 50 I.

Adjustable speed obtainable by magnetic drive is the subject of a 32-page technical publication, No. 1107, published by Electric Machinery Mfg. Co., Minneapolis 13, Minn. Descriptions of the operation of the units and some typical industrial applications are given.

Aluminum paint is the subject of a circular and price sheet on Prufcoat Aluminum distributed by Prufcoat Labs., 50 E. 42nd St., New York 17, N.Y.

Fire protection for drawings and plans is the subject of a booklet on the use of Safe-Cabinets and Files entitled "How Safe Are Your Drawings?" Copies may be obtained from Remington Rand, 315 4th Ave., New York 10, N.Y.

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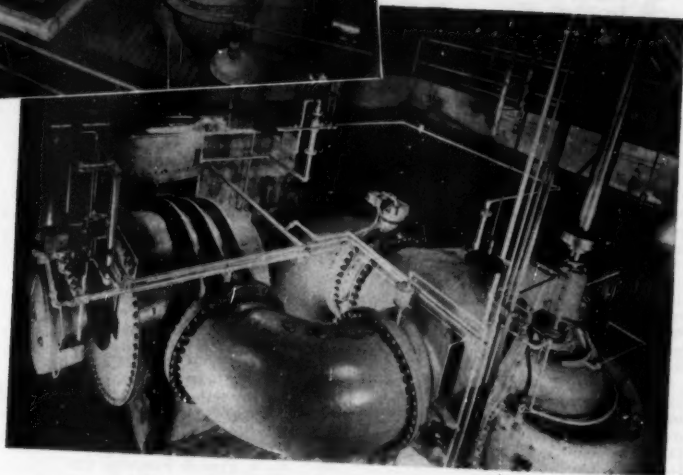
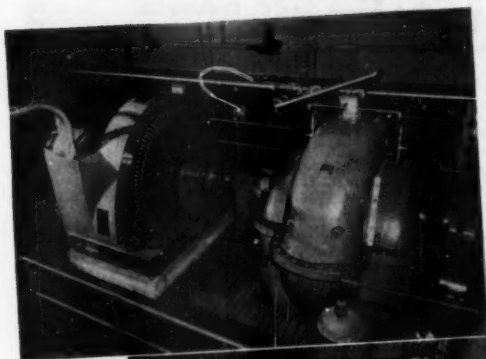
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COMING MEETINGS

(Continued from page viii)

October

4-5—West Virginia Section at Daniel Boone Hotel, Charleston. Secretary: Harry K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston 5, W.Va.

14-17—Southwest Section at Hotel Texas, Fort Worth, Tex. Secretary: Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

23-26—California Section at Fairmont Hotel, San Francisco. Secretary: William W. Aultman, Water Purification Engr., Metropolitan Water Dist. of Southern California, Box 38, LaVerne, Calif.

25-27—New Jersey Section at Madison Hotel, Atlantic City. Secretary: C. B. Tygert, Wallace & Tierman Co., Box 178, Newark 1, N.J.

25-27—Iowa Section at Hotel Julian, Dubuque. Secretary: H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown, Iowa.

28-31—Florida Section at Park Sheraton Hotel, Daytona Beach. Secretary: Marvin R. Boyce, 504 Pennsylvania Ave., Clearwater, Fla. (Joint meeting with Florida Sewage and Industrial Wastes Association.)

Oct. 31–November 2—Chesapeake Section at Sheraton-Belvedere Hotel, Baltimore, Md. Secretary: Carl J. Lauter, 5902 Dalecarlia Pl., N.W., Washington 16, D.C.

November

7-9—Virginia Section at Hotel Roanoke, Roanoke. Secretary: W. H. Shewbridge, Asst. Engr., State Dept. of Health, 708 State Office Bldg., Richmond 19, Va.

12-14—North Carolina Section at Robert E. Lee Hotel, Winston-Salem, N.C. Secretary: E. C. Hubbard, Principal San. Engr., State Board of Health, Raleigh, N.C.

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Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.

Chemists and Engineers:
(See Prof. Services, pp. 25-29)

Chlorination Equipment:
Builders-Providence, Inc.
Everson Mfg. Corp.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine Comparators:
Hellige, Inc.
Klett Mfg. Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Chlorine, Liquid:
Solvay Sales Div.
Wallace & Tiernan Co., Inc.

Clamps and Sleeves, Pipe:
R. H. Baker & Co., Inc.
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
James Jones Co.
Rensselaer Valve Co.
Skinner, M. B., Co.
A. P. Smith Mfg. Co.
Smith-Blair, Inc.

Clamps, Bell Joint:
Carson-Cadillac Co.
James B. Clow & Sons
Dresser Mfg. Div.

Skinner, M. B., Co.
Smith-Blair, Inc.

Clamps, Pipe Repair:
R. H. Baker & Co., Inc.
James B. Clow & Sons
Dresser Mfg. Div.
Skinner, M. B., Co.
Smith-Blair, Inc.
Warren Foundry & Pipe Corp.

Clarifiers:
American Well Works
Chain Belt Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Inflico Inc.
Permutit Co.
Walker Process Equipment, Inc.

Cleaning Water Mains:
Flexible Underground Pipe Cleaning Co.
National Water Main Cleaning Co.

Condensers:
United States Pipe & Foundry Co.

Contractors, Water Supply:
Boyce Co., Inc.
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc.
Inflico Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Tennessee Corp.

Corrosion Control:
Calgon, Inc.
Dearborn Chemical Co.

Couplings, Flexible:
R. H. Baker & Co., Inc.
DeLaval Steam Turbine Co.
Dresser Mfg. Div.
Philadelphia Gear Works, Inc.
Smith-Blair, Inc.

Diaphragms, Pump:
Dorr Co.
Morse Bros. Mch. Co.
Proportioneers, Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Prof. Services, pp. 25-29)

Feedwater Treatment:
Calgon, Inc.
Cochrane Corp.
Dearborn Chemical Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Worthington Pump & Mach. Corp.

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Johns-Manville Corp.
Inflico Inc.
Northern Gravel Co.
Permutit Co.

Filters, Incl. Feedwater:
Cochrane Corp.
Dorr Co.

Everson Mfg. Corp.
Inflico Inc.
Morse Bros. Mch. Co.
Permutit Co.
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
Builders-Providence, Inc.
Chain Belt Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.
Roberts Filter Mfg. Co.
Stuart Corp.
Welsbach Corp., Ozone Processes Div.
Worthington Pump & Mach. Corp.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Fittings, Tees, Elbs, etc.:
R. H. Baker & Co., Inc.
Carlton Products Corp.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Cochrane Corp.
Dorr Co.
Inflico Inc.
Permutit Co.
Stuart Corp.
Walker Process Equipment, Inc.

Fluoride Chemicals:
Aluminum Co. of America, Chemicals Div.
Blockson Chemical Co.

Furnaces:
Jos. G. Pollard Co., Inc.

Furnaces, Joint Compound:
Northrop & Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc.
Inflico Inc.
Simplex Valve & Meter Co.

Gages, Loss of Head, Rate of Flow, Sand Expansion:
Builders-Providence, Inc.
Inflico Inc.
Northrop & Co., Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Gasholders:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Northrop & Co., Inc.
Smith-Blair, Inc.

Gates, Shear and Stulce:
Armco Drainage & Metal Products, Inc.
James B. Clow & Sons



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GENERAL CHEMICAL "ALUM"

WATER experts agree—"alum" is the preferred coagulant for the removal of turbidity, color and other impurities in the water . . . and *General Chemical Aluminum Sulfate is the preferred "alum."*

SEWAGE experts agree—"alum" is preferred for the clarification of sewage because it flocs out the suspended solids and colloids . . . and *General Chemical Aluminum Sulfate is the preferred "alum."*

THE REASON: For over 50 years, General Chemical Aluminum Sulfate has been processed to meet the most rigid chemical and physical specifications. Its quality, uniformity and reliability are preferred by most cities the nation over. For your operations, *specify General Chemical "Alum."*



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In Wisconsin: General Chemical Company, Inc., Milwaukee, Wis.

In Canada: The Nichols Chemical Company, Limited
Montreal • Toronto • Vancouver

Morse Bros. Mch. Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.
Philadelphia Gear Works, Inc.

Glass Standards—Colorimetric Analysis Equipment:
Hellige, Inc.
Klett Mfg. Co.
Wallace & Tiernan Co., Inc.

Goose-necks (with or without Corporation Stops):
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Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Hydrants:
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M. Greenberg's Sons
James Jones Co.
Kennedy Valve Mfg. Co.
John C. Kupferle Foundry Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
Ross Valve Mfg. Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Ion Exchange Materials:
Cochrane Corp.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
R. H. Baker & Co., Inc.
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Line Slakers and Feeders:
Dorr Co.
Inflico Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.

Manometers, Rate of Flow:
Builders-Providence, Inc.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
R. H. Baker & Co., Inc.
Dresser Mfg. Div.

Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Smith-Blair, Inc.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Inflico Inc.
Simplex Valve & Meter Co.
R. W. Sparling

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
R. W. Sparling
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Inflico Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Pipe & Construction Co.
Lock Joint Pipe Co.
Price Bros. Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carlson Products Corp.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipelines, Submerged:
Boyce Co., Inc.

Pipes, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mch. Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Chemical Feed:
Inflico Inc.
Proportioners, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mch. Co.
Proportioners, Inc.

Pumps, Hydrant:
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.

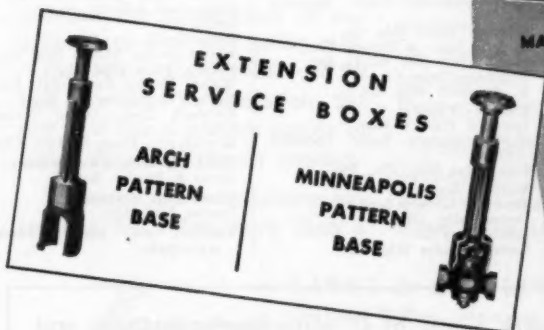
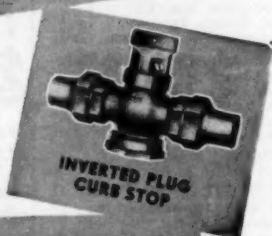
Rate Analysis:
Recording & Statistical Corp.

Recorders, Gas Density, CO₂, NH₃, SO₂, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.



OVER 80 years of manufacturing experience ... designed for easy installation ... long years of trouble-free service ... interchangeable with those of other manufacturers ... corporation stops can be installed with any standard tapping machine.

All Hays fittings made of single, uniform, high quality water service bronze, 85-5-5-5 mix ... hydrostatically tested at 200 pounds or more ... plugs individually ground in for perfect fit ... specially lubricated for permanent easy turning.



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Recording Instruments:

Builders-Providence, Inc.
Inflico Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:

Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages**Sleeves; see Clamps****Sleeves and Valves, Tapping:**

James B. Clow & Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:

Cochrane Corp.
Permutit Co.

Soda Ash:

Solvay Sales Div.

Sodium Hexametaphosphate:

Blackson Chemical Co.
Calgon, Inc.

Softeners:

Cochrane Corp.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Worthington Pump & Mach. Corp.

Softening Chemicals and Compounds:

Calgon, Inc.
Inflico Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:

Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:

Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Storage Tanks; see Tanks**Strainers, Suction:**

James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:

Permutit Co.

Swimming Pool Sterilization:

Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioners, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozon Processes Div.

Tanks, Steel:

Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:

Hays Mfg. Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:

Cochrane Corp.
Industrial Chemical Sales Div.
Inflico Inc.
Permutit Co.
Proportioners, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozon Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:

Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):

Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:

DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Turbines, Water:

DeLaval Steam Turbine Co.

Valve Boxes:

James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:

A. P. Smith Mfg. Co.

Valves, Altitude:

Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:

James B. Clow & Sons
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:

Hersey Mfg. Co.

Valves, Electrically Operated:

James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:

James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:

James B. Clow & Sons
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co.

M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:

James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:

James B. Clow & Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:

Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:

James B. Clow & Sons
Golden-Anderson Valve Specialty Co.

M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing

Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners**Water Supply Contractors:**

Layne & Bowler, Inc.

Water Testing Apparatus:

Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:

American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Inflico Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozon Processes Div.
Worthington Pump & Mach. Corp.

Well Drilling Contractors:

Layne & Bowler, Inc.

Wrenches, Ratchet:

Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

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FOR NACOGDOCHES, TEXAS

Over in the prosperous timber and agricultural belt of east Texas, the city of Nacogdoches is planning for further growth. Needing more water, municipal officials called in Layne and ordered the installation of another deep well and pump unit,—the third since 1925. With this new unit in operation, the city now has a greater supply of water than is presently needed.

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quarter century, have had every opportunity of failing—or proving their value in high efficiency, long life and absolute dependability. Since the first unit installed in 1925 is still producing its original capacity, Nacogdoches knew that they could do no better by changing types of equipment. They reasoned that they might do a lot worse.

Congratulations to Nacogdoches for the continued—and exclusive use of the world's finest wells and pumps.

LAYNE & BOWLER, INC.
General Offices, Memphis 8, Tenn.

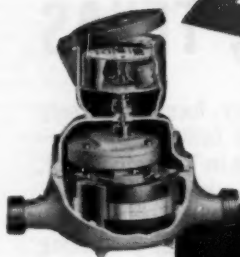
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WATER SUPPLY WELLS & PUMPS

Packed with Performance

Illustrating how working assembly is placed as a complete unit in Pittsburgh Arctic meter case. This same construction applies to Pittsburgh Tropic meters.

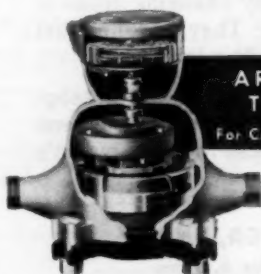


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For Warm Climates



**ARCTIC
TYPE**

For Cold Climates

Pittsburgh disc meters are precision built to keep the performance standards that have been so carefully engineered into them. Step by step—from controlled casting . . . through accurate machining and expert fitting—to exacting tests—Pittsburgh disc meters are *made right to measure right!* In addition, the unit assembly of working parts assures a free running mechanism that years hence can be repaired or replaced with minimum trouble and expense. Get all the facts about Rockwell disc meters now. *Write for catalog.*

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PITTSBURGH 8, PA.

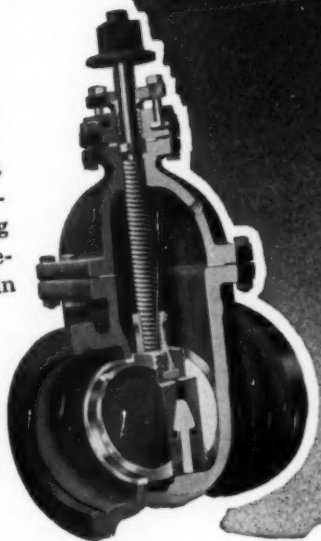
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HOW

TO BUY A VALVE

When you buy a valve, you buy pipe-line control—which encompasses valve design, construction, operation, first cost and maintenance. Purchase-price alone is not the determining factor. Price is relative. A high quality valve having longer life and giving better pipe-line control always is lowest in final cost.

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AND FITTINGS COMPANY
ANNISTON, ALABAMA



**DEPENDABLE SERVICE —
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Field reports establish the fact that M & H Valves are correctly designed, dependable in operation, with a record of long life and freedom from repair. Engineers recommend M & H Valves on basis of low cost per year of service. Sizes 2 to 30 inch, inclusive, with all standard end connections, including Mechanical Joint.

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Jointed for . . . Permanence with LEADITE

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Thus the "jointing material" used for bell and spigot Water Mains **MUST BE GOOD,—MUST BE DEPENDABLE,—**and that is just why so many Engineers, Water Works Men and Contractors aim to **PLAY ABSOLUTELY SAFE**, by specifying and using **LEADITE**.

Time has proven that **LEADITE** not only makes a tight durable joint,—but that it improves with age.

*The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%*

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Girard Trust Co. Bldg. Philadelphia, Pa.



No Caulking

